

10/510094

Rec'd PCT/PTO

05 OCT 2004

ETAU 2 / 01161

#2

PA 900633

REC'D 22 OCT 2002

TPO

PCT

THE UNITED STATES OF AMERICA**TO ALL TO WHOM THESE PRESENTS SHALL COME:****UNITED STATES DEPARTMENT OF COMMERCE****United States Patent and Trademark Office****September 24, 2002**

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 10/176,680**FILING DATE: June 24, 2002****PRIORITY
DOCUMENT****SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH RULE 17.1(a) OR (b)**

**By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS**



H. Phillips
H. PHILLIPS
Certifying Officer

BEST AVAILABLE COPY

Please type a plus sign (+) inside this box 

Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL

Attorney Docket No.	BAL20US
First Inventor	KIA SILVERBROOK
Title	Photographic Print Having Magnetically Recordable Media
Express Mail Label No.	

(Only for new nonprovisional applications under 37 CFR 1.53(b))

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)
2. ☒ Applicant claims small entity status.
See 37 CFR 1.27.
3. ☒ Specification [Total Pages 40]
(preferred arrangement set forth below)
 - Descriptive title of the invention
 - Cross Reference to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to sequence listing, a table, or a computer program listing appendix
 - Background of the invention
 - Brief Summary of the invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure
4. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 4]
5. Oath or Declaration [Total Pages 3]
 - a. ☒ Newly executed (original or copy)
 - b. ☐ Copy from a prior application (37 CFR 1.63 (d))
(for continuation/divisional with Box 17 completed)
 - c. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☐ Application Data Sheet. See 37 CFR 1.76

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

7. ☐ CD-ROM or CD-R in duplicate, large table or Computer Program (Appendix)
8. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
 - a. ☐ Computer Readable Form (CRF)
 - b. Specification Sequence Listing on:
 - i. ☐ CD-ROM or CD-R (2 copies); or
 - ii. ☐ paper
 - c. ☐ Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. ☒ Assignment Papers (cover sheet & document(s))
10. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
11. ☐ English Translation Document (if applicable)
12. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
13. ☐ Preliminary Amendment
14. ☐ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. ☐ Other:

17. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:

☐ Continuation ☐ Divisional ☒ Continuation-in-part (CIP)

of prior application No: 09 / 112,788

Prior application information:

Examiner Peter Kim

Group / Art Unit: 2851

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

18. CORRESPONDENCE ADDRESS

☒ Customer Number or Bar Code Label



or ☐ Correspondence address below

Name	KIA SILVERBROOK				
Address	393 Darling Street,				
City	Balmain	State	NSW	Zip Code	2041
Country	Australia	Telephone	+61-2-9818-6633	Fax	+61-2-9819-6711

Name (Print/Type)	KIA SILVERBROOK	Registration No. (Attorney/Agent)	
Signature		Date	June 21, 2002

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**FEE TRANSMITTAL
for FY 2002**

Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT (\$) 410

Complete if Known

Application Number	
Filing Date	
First Named Inventor	KIA SILVERBROOK
Examiner Name	
Group Art Unit	
Attorney Docket No.	BAL20US

METHOD OF PAYMENT (check all that apply)☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None☐ Deposit Account:

Deposit Account Number	
Deposit Account Name	

The Commissioner is authorized to: (check all that apply)

☐ Charge fee(s) indicated below ☐ Credit any overpayments
☐ Charge any additional fee(s) during the pendency of this application
☐ Charge fee(s) indicated below, except for the filing fee to the above identified deposit account.
FEE CALCULATION**1. BASIC FILING FEE**

Large Entity		Small Entity		Fee Description	Fee Paid
Fee Code	Fee (\$)	Fee Code	Fee (\$)		
101	740	201	370	Utility filing fee	370
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	

SUBTOTAL (1) (\$) 370

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

Total Claims		Extra Claims		Fee from below		Fee Paid	
Independent	Multiple Dependent	-20** =	-3** =	9	40		
5	1						

Large Entity		Small Entity		Fee Description	Fee Paid
Fee Code	Fee (\$)	Fee Code	Fee (\$)		
103	18	203	9	Claims in excess of 20	
102	84	202	42	Independent claims in excess of 3	
104	280	204	140	Multiple dependent claim, if not paid	
109	84	209	42	** Reissue independent claims over original patent	
110	18	210	9	** Reissue claims in excess of 20 and over original patent	

SUBTOTAL (2) (\$) 0

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)**3. ADDITIONAL FEES**

Large Entity		Small Entity		Fee Description	Fee Paid
Fee Code	Fee (\$)	Fee Code	Fee (\$)		
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for ex parte reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	217	460	Extension for reply within third month	
118	1,440	218	720	Extension for reply within fourth month	
128	1,860	228	930	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,280	241	640	Petition to revive - unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR 1.17(q)	
126	180	126	180	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40
146	740	246	370	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify)

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) (\$) 40

SUBMITTED BY

Name (Print/Type)	Kia Silverbrook	Registration No. (Attorney/Agent)		Telephone	+61-2-9818-6633
Signature				Date	June 21, 2002

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

This is a C-I-P of USSN 09/112,788 filed 10 July 1998

PHOTOGRAPHIC PRINTS HAVING MAGNETICALLY RECORDABLE MEDIA

5 CROSS REFERENCES TO RELATED APPLICATIONS

The following patent application is a continuation-in-part of patent application USSN 09/112,788 filed 10 July 1998, claiming priority from Australian provisional patent application AU PO9402.

- 10 The following patent applications are hereby incorporated by cross-reference. For the purposes of location and identification, US patent applications identified by their US patent application serial numbers (USSN) are listed alongside the Australian applications from which the US patent applications claim the right of priority.

CROSS-REFERENCED AUSTRALIAN PROVISIONAL PATENT APPLICATION NO.	US PATENT/PATENT APPLICATION (CLAIMING RIGHT OF PRIORITY FROM AUSTRALIAN PROVISIONAL APPLICATION)	DOCKET NO.
PO7991	09/113,060	ART01
PO7988	09/113,070	ART02
PO7993	09/113,073	ART03
PO9395	09/112,748	ART04
PO8017	09/112,747	ART06
PO8014	09/112,776	ART07
PO8025	09/112,750	ART08
PO8032	09/112,746	ART09
PO7999	09/112,743	ART10
PO7998	09/112,742	ART11
PO8031	09/112,741	ART12
PO8030	6,196,541	ART13
PO7997	6,195,150	ART15
PO7979	09/113,053	ART16
PO8015	09/112,738	ART17
PO7978	09/113,067	ART18
PO7982	09/113,063	ART19
PO7989	09/113,069	ART20
PO8019	09/112,744	ART21
PO7980	09/113,058	ART22
PO8018	09/112,777	ART24
PO7938	09/113,224	ART25
PO8016	09/112,804	ART26

CROSS-REFERENCED AUSTRALIAN PROVISIONAL PATENT APPLICATION NO.	US PATENT/PATENT APPLICATION (CLAIMING RIGHT OF PRIORITY FROM AUSTRALIAN PROVISIONAL APPLICATION)	DOCKET NO.
PO8024	09/112,805	ART27
PO7940	09/113,072	ART28
PO7939	09/112,785	ART29
PO8501	6,137,500	ART30
PO8500	09/112,796	ART31
PO7987	09/113,071	ART32
PO8022	09/112,824	ART33
PO8497	09/113,090	ART34
PO8020	09/112,823	ART38
PO8023	09/113,222	ART39
PO8504	09/112,786	ART42
PO8000	09/113,051	ART43
PO7977	09/112,782	ART44
PO7934	09/113,056	ART45
PO7990	09/113,059	ART46
PO8499	09/113,091	ART47
PO8502	09/112,753	ART48
PO7981	09/113,055	ART50
PO7986	09/113,057	ART51
PO7983	09/113,054	ART52
PO8026	09/112,752	ART53
PO8027	09/112,759	ART54
PO8028	09/112,757	ART56
PO9394	09/112,758	ART57
PO9396	09/113,107	ART58
PO9397	09/112,829	ART59
PO9398	09/112,792	ART60
PO9399	6,106,147	ART61
PO9400	09/112,790	ART62
PO9401	09/112,789	ART63
PO9402	09/112,788	ART64
PO9403	09/112,795	ART65
PO9405	09/112,749	ART66
PP0959	09/112,784	ART68
PP1397	6,217,165	ART69
PP2370	09/112,781	DOT01
PP2371	09/113,052	DOT02
PO8003	09/112,834	Fluid01
PO8005	09/113,103	Fluid02
PO9404	09/113,101	Fluid03
PO8066	6,227,652	IJ01
PO8072	6,213,588	IJ02
PO8040	6,213,589	IJ03

CROSS-REFERENCED AUSTRALIAN PROVISIONAL PATENT APPLICATION NO.	US PATENT/PATENT APPLICATION (CLAIMING RIGHT OF PRIORITY FROM AUSTRALIAN PROVISIONAL APPLICATION)	DOCKET NO.
PO8071	6,231,163	IJ04
PO8047	09/113,097	IJ05
PO8035	09/113,099	IJ06
PO8044	09/113,084	IJ07
PO8063	09/113,066	IJ08
PO8057	09/112,778	IJ09
PO8056	6,220,694	IJ10
PO8069	09/113,077	IJ11
PO8049	09/113,061	IJ12
PO8036	6,234,610	IJ13
PO8048	09/112,816	IJ14
PO8070	09/112,772	IJ15
PO8067	09/112,819	IJ16
PO8001	09/112,815	IJ17
PO8038	09/113,096	IJ18
PO8033	09/113,068	IJ19
PO8002	6,234,611	IJ20
PO8068	09/112,808	IJ21
PO8062	09/112,809	IJ22
PO8034	6,239,821	IJ23
PO8039	09/113,083	IJ24
PO8041	09/113,121	IJ25
PO8004	09/113,122	IJ26
PO8037	09/112,793	IJ27
PO8043	09/112,794	IJ28
PO8042	09/113,128	IJ29
PO8064	09/113,127	IJ30
PO9389	6,227,653	IJ31
PO9391	6,234,609	IJ32
PP0888	6,238,040	IJ33
PP0891	6,188,415	IJ34
PP0890	6,227,654	IJ35
PP0873	6,209,989	IJ36
PP0993	09/112,814	IJ37
PP0890	09/112,764	IJ38
PP1398	6,217,153	IJ39
PP2592	09/112,767	IJ40
PP2593	6,243,113	IJ41
PP3991	09/112,807	IJ42
PP3987	09/112,806	IJ43
PP3985	09/112,820	IJ44
PP3983	09/112,821	IJ45
PO7935	6,224,780	IJM01

CROSS-REFERENCED AUSTRALIAN PROVISIONAL PATENT APPLICATION No.	US PATENT/PATENT APPLICATION (CLAIMING RIGHT OF PRIORITY FROM AUSTRALIAN PROVISIONAL APPLICATION)	DOCKET No.
PO7936	6,235,212	IJM02
PO7937	09/112,826	IJM03
PO8061	09/112,827	IJM04
PO8054	6,214,244	IJM05
PO8065	6,071,750	IJM06
PO8055	09/113,108	IJM07
PO8053	09/113,109	IJM08
PO8078	09/113,123	IJM09
PO7933	6,225,138	IJM10
PO7950	09/113,115	IJM11
PO7949	09/113,129	IJM12
PO8060	09/113,124	IJM13
PO8059	6,231,773	IJM14
PO8073	6,190,931	IJM15
PO8076	09/113,119	IJM16
PO8075	09/113,120	IJM17
PO8079	09/113,221	IJM18
PO8050	09/113,116	IJM19
PO8052	09/113,118	IJM20
PO7948	09/113,117	IJM21
PO7951	6,231,772	IJM22
PO8074	09/113,130	IJM23
PO7941	09/113,110	IJM24
PO8077	09/113,112	IJM25
PO8058	09/113,087	IJM26
PO8051	09/113,074	IJM27
PO8045	6,110,754	IJM28
PO7952	09/113,088	IJM29
PO8046	09/112,771	IJM30
PO9390	09/112,769	IJM31
PO9392	09/112,770	IJM32
PP0889	6,235,211	IJM35
PP0887	09/112,801	IJM36
PP0882	09/112,800	IJM37
PP0874	09/112,799	IJM38
PP1396	09/113,098	IJM39
PP3989	09/112,833	IJM40
PP2591	6,180,427	IJM41
PP3990	6,171,875	IJM42
PP3986	09/112,830	IJM43
PP3984	6,245,247	IJM44
PP3982	09/112,835	IJM45
PP0895	6,231,148	IR01

CROSS-REFERENCED AUSTRALIAN PROVISIONAL PATENT APPLICATION NO.	US PATENT/PATENT APPLICATION (CLAIMING RIGHT OF PRIORITY FROM AUSTRALIAN PROVISIONAL APPLICATION)	DOCKET NO.
PP0870	09/113,106	IR02
PP0869	09/113,105	IR04
PP0887	09/113,104	IR05
PP0885	6,238,033	IR06
PP0884	09/112,766	IR10
PP0886	6,238,111	IR12
PP0871	09/113,086	IR13
PP0876	09/113,094	IR14
PP0877	09/112,760	IR16
PP0878	6,196,739	IR17
PP0879	09/112,774	IR18
PP0883	09/112,775	IR19
PP0880	6,152,619	IR20
PP0881	09/113,092	IR21
PO8006	6,087,638	MEMS02
PO8007	09/113,093	MEMS03
PO8008	09/113,062	MEMS04
PO8010	6,041,600	MEMS05
PO8011	09/113,082	MEMS06
PO7947	6,067,797	MEMS07
PO7944	09/113,080	MEMS09
PO7946	6,044,646	MEMS10
PO9393	09/113,065	MEMS11
PP0875	09/113,078	MEMS12
PP0894	09/113,075	MEMS13

FIELD OF THE INVENTION

The present invention relates to the field of digital image cameras and in particular, discloses a Camera and Media for Art Prints or Photos with Magnetically Recordable
5 Feature.

BACKGROUND OF THE INVENTION

The preferred embodiment is preferably implemented through modification of a hand held camera device such as that described in Patent Application USSN 09/113,060, which
10 claims priority from Australian provisional application No. PO7991 entitled "Image Processing Method and Apparatus" (Art 01) filed 15 July, 1997.

The aforementioned patent specification discloses a camera system, hereinafter

known as an "Artcam" type camera, wherein sensed images can be directly printed out by an Artcam portable camera unit. Further, the aforementioned specification discloses means and methods for performing various manipulations on images captured by the camera sensing device leading to the production of various effects in any output image. The manipulations
5 are disclosed to be highly flexible in nature and can be implemented through the insertion into the Artcam of cards having encoded thereon various instructions for the manipulation of images, the cards hereinafter being known as Artcards. The Artcam further has significant onboard processing power in an Artcam Central Processor unit (ACP) which is interconnected to a memory device for the storage of important data and images.

10 The Artcam camera system which a digital camera with an inbuilt integral color printer. Additionally, the camera provides hardware and software for the increasing of the apparent resolution of the image sensing system and the conversion of the image to a wide range of "artistic styles" and a graphic enhancement.

In one aspect, the Artcam camera system comprises at least one area image sensor for
15 imaging a scene, a camera processor means for processing said imaged scene in accordance with a predetermined scene transformation requirement, a printer for printing out said processed image scene on print media, print media and printing ink stored in a single detachable module inside said camera system, said camera system comprising a portable hand held unit for the imaging of scenes by said area image sensor and printing said scenes directly
20 out of said camera system via said printer.

Preferably the camera system includes a print roll for the storage of print media and printing ink for utilization by the printer, the print roll being detachable from the camera system. Further, the print roll can include an authentication chip containing authentication information and the camera processing means is adapted to interrogate the authentication chip
25 so as to determine the authenticity of said print roll when inserted within said camera system.

Further, the printer can include a drop on demand ink jet printer and guillotine means for the separation of printed photographs.

With such an arrangement, it would be desirable to be able to record ancillary information with each output photograph.

30 SUMMARY OF THE INVENTION

It is an object of the present invention to provide for the magnetic recording of information such as audio with a photo output by an Artcam device.

In accordance with a first aspect of the present invention, there is provided a camera system for the creation of images, the camera system comprising a sensor for sensing an image; a processing means for processing the sensed image in accordance with predetermined processing requirements; a printer means for printing the sensed image on the surface of print media, the print media including a magnetically sensitive surface; a magnetic recording means for recording associated information on the magnetically sensitive surface.

The associated information can comprise audio information associated with the sensed image and the printer means preferably prints the sensed image on a first surface of the print media and the magnetic recording means records the associated information on a second surface of the print media. The print media can be stored on an internal detachable roll in the camera system. In one embodiment, the magnetic sensitive surface can comprise a strip affixed to the back surface of the print media.

In accordance with a second aspect of the present invention, there is provided a camera system for recording images, said camera system comprising:

an electronic image sensor for sensing an image;

a digital processing means for processing said sensed image in accordance with predetermined processing requirements;

a photo width ink jet printer means for printing said processed image on a surface of ink jet print media, said ink jet print media including a magnetic recording surface;

a magnetic recording means for recording associated information on said magnetic recording surface.

Preferably, said associated information comprises audio information associated with said sensed image.

Preferably, the printer means prints said sensed image on a first surface of said print media and the magnetic recording means records said associated information on a second surface of said print media. Preferably, said first and said second surfaces are on different faces of said print media.

Preferably, said ink jet print media is stored on an internal detachable roll in said camera system, said camera system comprising a hand held portable camera device, said photo width ink jet printer being built into said hand held portable camera device.

BRIEF DESCRIPTION OF THE DRAWINGS

Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 illustrates schematically the camera system constructed in accordance to the preferred embodiment;

Fig. 2 illustrates schematically a printer mechanism and recording mechanism of the preferred embodiment.

Fig. 3 illustrates a format of the magnetic strip on the back of the photo;

Fig. 4 illustrates a reader device utilized to read data recorded on the back of a photograph; and

Fig. 5 illustrates the utilization of an apparatus of the preferred embodiment.

DESCRIPTION OF PREFERRED AND OTHER EMBODIMENTS

In the preferred embodiment a magnetic sensitive print media material is utilized for the recording of an audio message on the back of an output photograph. The Artcam device is altered so as to include a magnetic recording device which can comprise an array of magnetic recorders covering a whole surface of the photograph or alternatively, a magnetic strip can be provided wherein, for example, a central portion of the photograph is magnetically sensitive. The Artcam devices are further provided with the ability to record an audio message for later playback.

The preferred embodiment is preferably implemented through suitable programming of a hand held camera device such as that described in Australian Provisional Patent Application No. PO7991 USSN 09/113,060) entitled "Image Processing Method and Apparatus (Art 01)" filed 15 July, 1997.

The aforementioned patent specification discloses a camera system, hereinafter known as an "Artcam" type camera, wherein sensed images can be directly printed out by an Artcam portable camera unit. Further, the aforementioned specification discloses means and methods for performing various manipulations on images captured by the camera sensing device leading to the production of various effects in any output image. The manipulations are disclosed to be highly flexible in nature and can be implemented through the insertion into the Artcam of cards having encoded thereon various instructions for the manipulation of

images, the cards hereinafter being known as Artcards. The Artcam further has significant onboard processing power by an Artcam Central Processor unit (ACP) which is interconnected to a memory device for the storage of important data and images.

In the preferred embodiment, the Artcam device is suitably modified so as to equip it with a microphone device and associated recording technologies. When a picture is taken, the opportunity is provided to record either the surrounding sound environment or a message associated with the image. The print media or film is pretreated so as to make it magnetically sensitive in a similar manner to that provided by tape media. The recording can be over the whole back surface of the output photo or alternatively a magnetically sensitive strip may be provided. The recorded audio is stored on the back of the output photograph in an encoded format, the encoding preferably being of a highly digital resilient form. The recorded audio provides a permanent audio record associated with the corresponding photograph. Subsequently, a playback apparatus is provided for scanning the encoded audio and decoding this information.

Turning now to Fig. 1, there is illustrated, in schematic form the preferred embodiment 1 which includes the arrangement as described in the aforementioned patent specification wherein an image 2 is sensed via a CCD sensor 3 and forwarded to an Artcam central processor 4 which includes significant computational resources as described in the aforementioned patent specification. The Artcam central processor 4 can store the image in memory 5 which preferably comprises a high speed RAMBUS (Trade Mark) interfaced memory. The Artcam central processor 4 is also responsible for controlling the operation of a printhead 6 for the printing out of full colour photographs, eg. 7, so as to provide for instant images on demand in addition to the magnetic recording head 16, for recording on the back of the photo.

In the preferred embodiment, the camera arrangement 1 is also supplied with a sound chip 10 which interfaces via RAMBUS bus 11 to memory 5 under the control of the ACP processor 4. The sound chip 10 can be of a standard or specialised form and can, for example, comprise a DSP processor that takes an analogue input 12 from a sound microphone 13. Alternatively, with increasing chip complexities (Moore's Law), the functionality of sound chip 10 can be incorporated onto the ACP chip 4 which preferably comprises a leading edge CMOS type integrated circuit chip. It will be readily evident that many other types of arrangements can be provided which fall within the scope of the present invention.

The sound chip 10 converts the analogue input 12 to a corresponding digital form and forwards it for storage in memory 5. The recording process can be activated by means of the depressing of a button (not shown) on the camera device, the button being under the control of the ACP processor 4 otherwise it can be substantially automatic when taking a photo. The recorded data is stored in the memory 5.

Turning now to Fig. 2, the camera arrangement preferably includes a printer device 6 such as an ink jet printer which includes a printhead 6 to print an image on compatible print media 17 and a magnetic recording head 16. A further printhead can be used to print information on the back of print media 17. Similar arrangements for printing information on the back of an output photo image are described in USSN 09/112,741 (Art 12) the contents of which are hereby incorporated by cross reference.

Turning now to Fig. 3, there is illustrated an example of a magnetic strip 18 formed on the back of photo media 17, the strip being recorded on by recording head 16 of Fig. 1 or Fig. 2. The information recorded can include location, date and time data with the location data being provided by means of keyboard input or, alternatively, through the inclusion of a positioning systems such as GPS or the like. Fig 4 shows the back of the image 17 on which is also recorded an encoded form 22 of the audio information. The format of the encoding can be any form within the knowledge of the person skilled in the art. However, preferably the encoding provides a highly fault tolerant form of encoding to tolerate errors that may arise due to use and handling of the print media. The encoding format can be, for example, Reed-Solomon encoding of the data to provide for a high degree of fault tolerance.

Turning to Fig. 4, when it is desired to "play back" the recorded audio, the photo 17 is passed through a reader device 26 which includes pinch rollers for guiding the photo 17 past a magnetic sensor device 27.

Referring now to Fig. 5, there is illustrated in schematic form the operation of the audio reader device 26 of Fig. 5. The magnetic sensor 27 is interconnected to a second Artcam central processor (ACP) 28 which is suitably adapted to read and decode the data stored on the back of the photograph. The decoded audio information is stored in memory 32 for playback via a sound processing chip 35 on speaker 29. The sound processing chip 35 can operate under the control of the ACP decoder 28 which in turn operates under the control of various user input controls 33 which can include volume controls, rewind, play and fast forward controls etc.

It can be seen from the foregoing description of the preferred embodiment that there is provided a system for the automatic recording of audio associated with an output image so as to provide an audio record associated with a photograph printed on ink jet media. There is also disclosed an audio reader system for reading an image recorded on the back of such a photograph.

It would be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiment without departing from the spirit or scope of the invention as broadly described. For example, the utilisation of more complex audio recording and playback techniques such as stereo and B-format techniques. The present embodiment is, therefore, to be considered in all respects to be illustrative and not restrictive.

Ink Jet Technologies

The embodiments of the invention use an ink jet printer type device. Of course many different devices could be used. However presently popular ink jet printing technologies are unlikely to be suitable.

The most significant problem with thermal ink jet is power consumption. This is approximately 100 times that required for high speed, and stems from the energy-inefficient means of drop ejection. This involves the rapid boiling of water to produce a vapor bubble which expels the ink. Water has a very high heat capacity, and must be superheated in thermal ink jet applications. This leads to an efficiency of around 0.02%, from electricity input to drop momentum (and increased surface area) out.

The most significant problem with piezoelectric ink jet is size and cost. Piezoelectric crystals have a very small deflection at reasonable drive voltages, and therefore require a large area for each nozzle. Also, each piezoelectric actuator must be connected to its drive circuit on a separate substrate. This is not a significant problem at the current limit of around 300 nozzles per print head, but is a major impediment to the fabrication of pagewide print heads with 19,200 nozzles.

Ideally, the ink jet technologies used meet the stringent requirements of in-camera digital color printing and other high quality, high speed, low cost printing applications. To meet the requirements of digital photography, new ink jet technologies have been created. The target features include:

- low power (less than 10 Watts)
- high resolution capability (1,600 dpi or more)

photographic quality output
 low manufacturing cost
 small size (pagewidth times minimum cross section)
 high speed (< 2 seconds per page).

All of these features can be met or exceeded by the ink jet systems described below with differing levels of difficulty. 45 different ink jet technologies have been developed by the Assignee to give a wide range of choices for high volume manufacture. These technologies form part of separate applications assigned to the present Assignee as set out in the table below..

The ink jet designs shown here are suitable for a wide range of digital printing systems, from battery powered one-time use digital cameras, through to desktop and network printers, and through to commercial printing systems.

For ease of manufacture using standard process equipment, the print head is designed to be a monolithic 0.5 micron CMOS chip with MEMS post processing. For color photographic applications, the print head is 100 mm long, with a width which depends upon the ink jet type. The smallest print head designed is IJ38, which is 0.35 mm wide, giving a chip area of 35 square mm. The print heads each contain 19,200 nozzles plus data and control circuitry.

Ink is supplied to the back of the print head by injection molded plastic ink channels.

The molding requires 50 micron features, which can be created using a lithographically micromachined insert in a standard injection molding tool. Ink flows through holes etched through the wafer to the nozzle chambers fabricated on the front surface of the wafer. The print head is connected to the camera circuitry by tape automated bonding.

Tables of Drop-on-Demand Ink Jets

Eleven important characteristics of the fundamental operation of individual ink jet nozzles have been identified. These characteristics are largely orthogonal, and so can be elucidated as an eleven dimensional matrix. Most of the eleven axes of this matrix include entries developed by the present assignee.

The following tables form the axes of an eleven dimensional table of ink jet types.

- Actuator mechanism (18 types)
- Basic operation mode (7 types)
- Auxiliary mechanism (8 types)
- Actuator amplification or modification method (17 types)

Actuator motion (19 types)

Nozzle refill method (4 types)

Method of restricting back-flow through inlet (10 types)

Nozzle clearing method (9 types)

Nozzle plate construction (9 types)

Drop ejection direction (5 types)

Ink type (7 types)

The complete eleven dimensional table represented by these axes contains 36.9 billion possible configurations of ink jet nozzle. While not all of the possible combinations result in a viable ink jet technology, many million configurations are viable. It is clearly impractical to elucidate all of the possible configurations. Instead, certain ink jet types have been investigated in detail. These are designated IJ01 to IJ45 above.

Other ink jet configurations can readily be derived from these 45 examples by substituting alternative configurations along one or more of the 11 axes. Most of the IJ01 to IJ45 examples can be made into ink jet print heads with characteristics superior to any currently available ink jet technology.

Where there are prior art examples known to the inventor, one or more of these examples are listed in the examples column of the tables below. The IJ01 to IJ45 series are also listed in the examples column. In some cases, a printer may be listed more than once in a table, where it shares characteristics with more than one entry.

Suitable applications for the ink jet technologies include: Home printers, Office network printers, Short run digital printers, Commercial print systems, Fabric printers, Pocket printers, Internet WWW printers, Video printers, Medical imaging, Wide format printers, Notebook PC printers, Fax machines, Industrial printing systems, Photocopiers, Photographic minilabs etc.

The information associated with the aforementioned 11 dimensional matrix are set out in the following tables.

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
Thermal bubble	<p>An electrothermal heater heats the ink to above boiling point, transferring significant heat to the aqueous ink. A bubble nucleates and quickly forms, expelling the ink.</p> <p>The efficiency of the process is low, with typically less than 0.05% of the electrical energy being transformed into kinetic energy of the drop.</p>	<ul style="list-style-type: none"> ♦ Large force generated ♦ Simple construction ♦ No moving parts ♦ Fast operation ♦ Small chip area required for actuator 	<ul style="list-style-type: none"> ♦ High power ♦ Ink carrier limited to water ♦ Low efficiency ♦ High temperatures required ♦ High mechanical stress ♦ Unusual materials required ♦ Large drive transistors ♦ Cavitation causes actuator failure ♦ Kogation reduces bubble formation ♦ Large print heads are difficult to fabricate 	<ul style="list-style-type: none"> ♦ Canon Bubblejet 1979 Endo et al GB patent 2,007,162 ♦ Xerox heater-in-pit 1990 Hawkins et al USP 4,899,181 ♦ Hewlett-Packard TIJ 1982 Vaught et al USP 4,490,728
Piezo-electric	<p>A piezoelectric crystal such as lead lanthanum zirconate (PZT) is electrically activated, and either expands, shears, or bends to apply pressure to the ink, ejecting drops.</p>	<ul style="list-style-type: none"> ♦ Low power consumption ♦ Many ink types can be used ♦ Fast operation ♦ High efficiency 	<ul style="list-style-type: none"> ♦ Very large area required for actuator ♦ Difficult to integrate with electronics ♦ High voltage drive transistors required ♦ Full pagewidth print heads impractical due to actuator size ♦ Requires electrical poling in high field strengths during manufacture 	<ul style="list-style-type: none"> ♦ Kyser et al USP 3,946,398 ♦ Zoltan USP 3,683,212 ♦ 1973 Stemme USP 3,747,120 ♦ Epson Stylus ♦ Tektronix ♦ IJ04
Electro-strictive	<p>An electric field is used to activate electrostriction in relaxor materials such as lead lanthanum zirconate titanate (PLZT) or lead magnesium niobate (PMN).</p>	<ul style="list-style-type: none"> ♦ Low power consumption ♦ Many ink types can be used ♦ Low thermal expansion ♦ Electric field strength required (approx. 3.5 V/μm) can be generated without difficulty ♦ Does not require electrical poling 	<ul style="list-style-type: none"> ♦ Low maximum strain (approx. 0.01%) ♦ Large area required for actuator due to low strain ♦ Response speed is marginal ($\sim 10 \mu$s) ♦ High voltage drive transistors required ♦ Full pagewidth print heads impractical due to actuator size 	<ul style="list-style-type: none"> ♦ Seiko Epson, Usui et al JP 253401/96 ♦ IJ04

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
Ferro-electric	An electric field is used to induce a phase transition between the antiferroelectric (AFE) and ferroelectric (FE) phase. Perovskite materials such as tin modified lead lanthanum zirconate titanate (PLZSnT) exhibit large strains of up to 1% associated with the AFE to FE phase transition.	<ul style="list-style-type: none"> ♦ Low power consumption ♦ Many ink types can be used ♦ Fast operation ($< 1 \mu\text{s}$) ♦ Relatively high longitudinal strain ♦ High efficiency ♦ Electric field strength of around $3 \text{ V}/\mu\text{m}$ can be readily provided 	<ul style="list-style-type: none"> ♦ Difficult to integrate with electronics ♦ Unusual materials such as PLZSnT are required ♦ Actuators require a large area 	♦ IJ04
Electro-static plates	Conductive plates are separated by a compressible or fluid dielectric (usually air). Upon application of a voltage, the plates attract each other and displace ink, causing drop ejection. The conductive plates may be in a comb or honeycomb structure, or stacked to increase the surface area and therefore the force.	<ul style="list-style-type: none"> ♦ Low power consumption ♦ Many ink types can be used ♦ Fast operation 	<ul style="list-style-type: none"> ♦ Difficult to operate electrostatic devices in an aqueous environment ♦ The electrostatic actuator will normally need to be separated from the ink ♦ Very large area required to achieve high forces ♦ High voltage drive transistors may be required ♦ Full pagewidth print heads are not competitive due to actuator size 	♦ IJ02, IJ04
Electro-static pull on ink	A strong electric field is applied to the ink, whereupon electrostatic attraction accelerates the ink towards the print medium.	<ul style="list-style-type: none"> ♦ Low current consumption ♦ Low temperature 	<ul style="list-style-type: none"> ♦ High voltage required ♦ May be damaged by sparks due to air breakdown ♦ Required field strength increases as the drop size decreases ♦ High voltage drive transistors required ♦ Electrostatic field attracts dust 	<ul style="list-style-type: none"> ♦ 1989 Saito et al, USP 4,799,068 ♦ 1989 Miura et al, USP 4,810,954 ♦ Tone-jet

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
Permanent magnet electro-magnetic	An electromagnet directly attracts a permanent magnet, displacing ink and causing drop ejection. Rare earth magnets with a field strength around 1 Tesla can be used. Examples are: Samarium Cobalt (SaCo) and magnetic materials in the neodymium iron boron family (NdFeB, NdDyFeBNb, NdDyFeB, etc)	<ul style="list-style-type: none"> ◆ Low power consumption ◆ Many ink types can be used ◆ Fast operation ◆ High efficiency ◆ Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> ◆ Complex fabrication ◆ Permanent magnetic material such as Neodymium Iron Boron (NdFeB) required. ◆ High local currents required ◆ Copper metalization should be used for long electromigration lifetime and low resistivity ◆ Pigmented inks are usually infeasible ◆ Operating temperature limited to the Curie temperature (around 540 K) 	◆ IJ07, IJ10
Soft magnetic core electro-magnetic	A solenoid induced a magnetic field in a soft magnetic core or yoke fabricated from a ferrous material such as electroplated iron alloys such as CoNiFe [1], CoFe, or NiFe alloys. Typically, the soft magnetic material is in two parts, which are normally held apart by a spring. When the solenoid is actuated, the two parts attract, displacing the ink.	<ul style="list-style-type: none"> ◆ Low power consumption ◆ Many ink types can be used ◆ Fast operation ◆ High efficiency ◆ Easy extension from single nozzles to pagewidth print heads ◆ 	<ul style="list-style-type: none"> ◆ Complex fabrication ◆ Materials not usually present in a CMOS fab such as NiFe, CoNiFe, or CoFe are required ◆ High local currents required ◆ Copper metalization should be used for long electromigration lifetime and low resistivity ◆ Electroplating is required ◆ High saturation flux density is required (2.0-2.1 T is achievable with CoNiFe [1]) 	◆ IJ01, IJ05, IJ08, IJ10, IJ12, IJ14, IJ15, IJ17

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
Lorenz force	<p>The Lorenz force acting on a current carrying wire in a magnetic field is utilized.</p> <p>This allows the magnetic field to be supplied externally to the print head, for example with rare earth permanent magnets.</p> <p>Only the current carrying wire need be fabricated on the print-head, simplifying materials requirements.</p>	<ul style="list-style-type: none"> ♦ Low power consumption ♦ Many ink types can be used ♦ Fast operation ♦ High efficiency ♦ Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> ♦ Force acts as a twisting motion ♦ Typically, only a quarter of the solenoid length provides force in a useful direction ♦ High local currents required ♦ Copper metalization should be used for long electromigration lifetime and low resistivity ♦ Pigmented inks are usually infeasible 	<ul style="list-style-type: none"> ♦ UJ06, UJ11, UJ13, UJ16
Magnetostriction	<p>The actuator uses the giant magnetostrictive effect of materials such as Terfenol-D (an alloy of terbium, dysprosium and iron developed at the Naval Ordnance Laboratory, hence Ter-Fe-NOL).</p> <p>For best efficiency, the actuator should be pre-stressed to approx. 8 MPa.</p>	<ul style="list-style-type: none"> ♦ Many ink types can be used ♦ Fast operation ♦ Easy extension from single nozzles to pagewidth print heads ♦ High force is available 	<ul style="list-style-type: none"> ♦ Force acts as a twisting motion ♦ Unusual materials such as Terfenol-D are required ♦ High local currents required ♦ Copper metalization should be used for long electromigration lifetime and low resistivity ♦ Pre-stressing may be required 	<ul style="list-style-type: none"> ♦ Fischenbeck, USP 4,032,929 ♦ UJ25
Surface tension reduction	<p>Ink under positive pressure is held in a nozzle by surface tension. The surface tension of the ink is reduced below the bubble threshold, causing the ink to egress from the nozzle.</p>	<ul style="list-style-type: none"> ♦ Low power consumption ♦ Simple construction ♦ No unusual materials required in fabrication ♦ High efficiency ♦ Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> ♦ Requires supplementary force to effect drop separation ♦ Requires special ink surfactants ♦ Speed may be limited by surfactant properties 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
Viscosity reduction	The ink viscosity is locally reduced to select which drops are to be ejected. A viscosity reduction can be achieved electrothermally with most inks, but special inks can be engineered for a 100:1 viscosity reduction.	<ul style="list-style-type: none"> Simple construction No unusual materials required in fabrication Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> Requires supplementary force to effect drop separation Requires special ink viscosity properties High speed is difficult to achieve Requires oscillating ink pressure A high temperature difference (typically 80 degrees) is required 	<ul style="list-style-type: none"> Silverbrook, EP 0771 658 A2 and related patent applications
Acoustic	An acoustic wave is generated and focussed upon the drop ejection region.	<ul style="list-style-type: none"> Can operate without a nozzle plate 	<ul style="list-style-type: none"> Complex drive circuitry Complex fabrication Low efficiency Poor control of drop position Poor control of drop volume 	<ul style="list-style-type: none"> 1993 Hadimioglu et al, EUP 550,192 1993 Elrod et al, EUP 572,220
Thermo-elastic bend actuator	An actuator which relies upon differential thermal expansion upon Joule heating is used.	<ul style="list-style-type: none"> Low power consumption Many ink types can be used Simple planar fabrication Small chip area required for each actuator Fast operation High efficiency CMOS compatible voltages and currents Standard MEMS processes can be used Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> Efficient aqueous operation requires a thermal insulator on the hot side Corrosion prevention can be difficult Pigmented inks may be infeasible, as pigment particles may jam the bend actuator 	<ul style="list-style-type: none"> IJ03, IJ09, IJ17, IJ18, IJ19, IJ20, IJ21, IJ22, IJ23, IJ24, IJ27, IJ28, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ35, IJ36, IJ37, IJ38, IJ39, IJ40, IJ41

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
High CTE thermo-elastic actuator	<p>A material with a very high coefficient of thermal expansion (CTE) such as polytetrafluoroethylene (PTFE) is used. As high CTE materials are usually non-conductive, a heater fabricated from a conductive material is incorporated. A 50 μm long PTFE bend actuator with polysilicon heater and 15 mW power input can provide 180 μN force and 10 μm deflection. Actuator motions include:</p> <p>Bend Push Buckle Rotate</p>	<ul style="list-style-type: none"> ◆ High force can be generated ◆ Three methods of PTFE deposition are under development: chemical vapor deposition (CVD), spin coating, and evaporation ◆ PTFE is a candidate for low dielectric constant insulation in ULSI ◆ Very low power consumption ◆ Many ink types can be used ◆ Simple planar fabrication ◆ Small chip area required for each actuator ◆ Fast operation ◆ High efficiency ◆ CMOS compatible voltages and currents ◆ Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> ◆ Requires special material (e.g. PTFE) ◆ Requires a PTFE deposition process, which is not yet standard in ULSI fabs ◆ PTFE deposition cannot be followed with high temperature (above 350 °C) processing ◆ Pigmented inks may be infeasible, as pigment particles may jam the bend actuator 	<ul style="list-style-type: none"> ◆ IJ09, IJ17, IJ18, IJ20, IJ21, IJ22, IJ23, IJ24, IJ27, IJ28, IJ29, IJ30, IJ31, IJ42, IJ43, IJ44
Conduct-ive polymer thermo-elastic actuator	<p>A polymer with a high coefficient of thermal expansion (such as PTFE) is doped with conducting substances to increase its conductivity to about 3 orders of magnitude below that of copper. The conducting polymer expands when resistively heated.</p> <p>Examples of conducting dopants include:</p> <p>Carbon nanotubes Metal fibers Conductive polymers such as doped polythiophene Carbon granules</p>	<ul style="list-style-type: none"> ◆ High force can be generated ◆ Very low power consumption ◆ Many ink types can be used ◆ Simple planar fabrication ◆ Small chip area required for each actuator ◆ Fast operation ◆ High efficiency ◆ CMOS compatible voltages and currents ◆ Easy extension from single nozzles to pagewidth print heads 	<ul style="list-style-type: none"> ◆ Requires special materials development (High CTE conductive polymer) ◆ Requires a PTFE deposition process, which is not yet standard in ULSI fabs ◆ PTFE deposition cannot be followed with high temperature (above 350 °C) processing ◆ Evaporation and CVD deposition techniques cannot be used ◆ Pigmented inks may be infeasible, as pigment particles may jam the bend actuator 	<ul style="list-style-type: none"> ◆ IJ24

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)				
	Description	Advantages	Disadvantages	Examples
Shape memory alloy	A shape memory alloy such as TiNi (also known as Nitinol - Nickel Titanium alloy developed at the Naval Ordnance Laboratory) is thermally switched between its weak martensitic state and its high stiffness austenitic state. The shape of the actuator in its martensitic state is deformed relative to the austenitic shape. The shape change causes ejection of a drop.	<ul style="list-style-type: none"> ♦ High force is available (stresses of hundreds of MPa) ♦ Large strain is available (more than 3%) ♦ High corrosion resistance ♦ Simple construction ♦ Easy extension from single nozzles to pagewidth print heads ♦ Low voltage operation 	<ul style="list-style-type: none"> ♦ Fatigue limits maximum number of cycles ♦ Low strain (1%) is required to extend fatigue resistance ♦ Cycle rate limited by heat removal ♦ Requires unusual materials (TiNi) ♦ The latent heat of transformation must be provided ♦ High current operation ♦ Requires pre-stressing to distort the martensitic state 	♦ IJ26
Linear Magnetic Actuator	Linear magnetic actuators include the Linear Induction Actuator (LIA), Linear Permanent Magnet Synchronous Actuator (LPMSA), Linear Reluctance Synchronous Actuator (LRSA), Linear Switched Reluctance Actuator (LSRA), and the Linear Stepper Actuator (LSA).	<ul style="list-style-type: none"> ♦ Linear Magnetic actuators can be constructed with high thrust, long travel, and high efficiency using planar semiconductor fabrication techniques ♦ Long actuator travel is available ♦ Medium force is available ♦ Low voltage operation 	<ul style="list-style-type: none"> ♦ Requires unusual semiconductor materials such as soft magnetic alloys (e.g. CoNiFe) ♦ Some varieties also require permanent magnetic materials such as Neodymium iron boron (NdFeB) ♦ Requires complex multi-phase drive circuitry ♦ High current operation 	♦ IJ12

BASIC OPERATION MODE				
	Description	Advantages	Disadvantages	Examples

BASIC OPERATION MODE				
	Description	Advantages	Disadvantages	Examples
Actuator directly pushes ink	This is the simplest mode of operation: the actuator directly supplies sufficient kinetic energy to expel the drop. The drop must have a sufficient velocity to overcome the surface tension.	<ul style="list-style-type: none"> Simple operation No external fields required Satellite drops can be avoided if drop velocity is less than 4 m/s Can be efficient, depending upon the actuator used 	<ul style="list-style-type: none"> Drop repetition rate is usually limited to around 10 kHz. However, this is not fundamental to the method, but is related to the refill method normally used All of the drop kinetic energy must be provided by the actuator Satellite drops usually form if drop velocity is greater than 4.5 m/s 	<ul style="list-style-type: none"> Thermal ink jet Piezoelectric ink jet IJ01, IJ02, IJ03, IJ04, IJ05, IJ06, IJ07, IJ09, IJ11, IJ12, IJ14, IJ16, IJ20, IJ22, IJ23, IJ24, IJ25, IJ26, IJ27, IJ28, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ35, IJ36, IJ37, IJ38, IJ39, IJ40, IJ41, IJ42, IJ43, IJ44
Proximity	The drops to be printed are selected by some manner (e.g. thermally induced surface tension reduction of pressurized ink). Selected drops are separated from the ink in the nozzle by contact with the print medium or a transfer roller.	<ul style="list-style-type: none"> Very simple print head fabrication can be used The drop selection means does not need to provide the energy required to separate the drop from the nozzle 	<ul style="list-style-type: none"> Requires close proximity between the print head and the print media or transfer roller May require two print heads printing alternate rows of the image Monolithic color print heads are difficult 	<ul style="list-style-type: none"> Silverbrook, EP 0771 658 A2 and related patent applications
Electro-static pull on ink	The drops to be printed are selected by some manner (e.g. thermally induced surface tension reduction of pressurized ink). Selected drops are separated from the ink in the nozzle by a strong electric field.	<ul style="list-style-type: none"> Very simple print head fabrication can be used The drop selection means does not need to provide the energy required to separate the drop from the nozzle 	<ul style="list-style-type: none"> Requires very high electrostatic field Electrostatic field for small nozzle sizes is above air breakdown Electrostatic field may attract dust 	<ul style="list-style-type: none"> Silverbrook, EP 0771 658 A2 and related patent applications Tone-Jet
Magnetic pull on ink	The drops to be printed are selected by some manner (e.g. thermally induced surface tension reduction of pressurized ink). Selected drops are separated from the ink in the nozzle by a strong magnetic field acting on the magnetic ink.	<ul style="list-style-type: none"> Very simple print head fabrication can be used The drop selection means does not need to provide the energy required to separate the drop from the nozzle 	<ul style="list-style-type: none"> Requires magnetic ink Ink colors other than black are difficult Requires very high magnetic fields 	<ul style="list-style-type: none"> Silverbrook, EP 0771 658 A2 and related patent applications

BASIC OPERATION MODE				
	Description	Advantages	Disadvantages	Examples
Shutter	The actuator moves a shutter to block ink flow to the nozzle. The ink pressure is pulsed at a multiple of the drop ejection frequency.	<ul style="list-style-type: none"> High speed (>50 kHz) operation can be achieved due to reduced refill time Drop timing can be very accurate The actuator energy can be very low 	<ul style="list-style-type: none"> Moving parts are required Requires ink pressure modulator Friction and wear must be considered Stiction is possible 	<ul style="list-style-type: none"> IJ13, IJ17, IJ21
Shuttered grill	The actuator moves a shutter to block ink flow through a grill to the nozzle. The shutter movement need only be equal to the width of the grill holes.	<ul style="list-style-type: none"> Actuators with small travel can be used Actuators with small force can be used High speed (>50 kHz) operation can be achieved 	<ul style="list-style-type: none"> Moving parts are required Requires ink pressure modulator Friction and wear must be considered Stiction is possible 	<ul style="list-style-type: none"> IJ08, IJ15, IJ18, IJ19
Pulsed magnetic pull on ink pusher	A pulsed magnetic field attracts an 'ink pusher' at the drop ejection frequency. An actuator controls a catch, which prevents the ink pusher from moving when a drop is not to be ejected.	<ul style="list-style-type: none"> Extremely low energy operation is possible No heat dissipation problems 	<ul style="list-style-type: none"> Requires an external pulsed magnetic field Requires special materials for both the actuator and the ink pusher Complex construction 	<ul style="list-style-type: none"> IJ10

AUXILIARY MECHANISM (APPLIED TO ALL NOZZLES)				
	Description	Advantages	Disadvantages	Examples
None	The actuator directly fires the ink drop, and there is no external field or other mechanism required.	<ul style="list-style-type: none"> Simplicity of construction Simplicity of operation Small physical size 	<ul style="list-style-type: none"> Drop ejection energy must be supplied by individual nozzle actuator 	<ul style="list-style-type: none"> Most ink jets, including piezoelectric and thermal bubble. IJ01, IJ02, IJ03, IJ04, IJ05, IJ07, IJ09, IJ11, IJ12, IJ14, IJ20, IJ22, IJ23, IJ24, IJ25, IJ26, IJ27, IJ28, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ35, IJ36, IJ37, IJ38, IJ39, IJ40, IJ41, IJ42, IJ43, IJ44

AUXILIARY MECHANISM (APPLIED TO ALL NOZZLES)				
	Description	Advantages	Disadvantages	Examples
Oscillating ink pressure (including acoustic stimulation)	The ink pressure oscillates, providing much of the drop ejection energy. The actuator selects which drops are to be fired by selectively blocking or enabling nozzles. The ink pressure oscillation may be achieved by vibrating the print head, or preferably by an actuator in the ink supply.	<ul style="list-style-type: none"> ♦ Oscillating ink pressure can provide a refill pulse, allowing higher operating speed ♦ The actuators may operate with much lower energy ♦ Acoustic lenses can be used to focus the sound on the nozzles 	<ul style="list-style-type: none"> ♦ Requires external ink pressure oscillator ♦ Ink pressure phase and amplitude must be carefully controlled ♦ Acoustic reflections in the ink chamber must be designed for 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ IJ08, IJ13, IJ15, IJ17, IJ18, IJ19, IJ21
Media proximity	The print head is placed in close proximity to the print medium. Selected drops protrude from the print head further than unselected drops, and contact the print medium. The drop soaks into the medium fast enough to cause drop separation.	<ul style="list-style-type: none"> ♦ Low power ♦ High accuracy ♦ Simple print head construction 	<ul style="list-style-type: none"> ♦ Precision assembly required ♦ Paper fibers may cause problems ♦ Cannot print on rough substrates 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications
Transfer roller	Drops are printed to a transfer roller instead of straight to the print medium. A transfer roller can also be used for proximity drop separation.	<ul style="list-style-type: none"> ♦ High accuracy ♦ Wide range of print substrates can be used ♦ Ink can be dried on the transfer roller 	<ul style="list-style-type: none"> ♦ Bulky ♦ Expensive ♦ Complex construction 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ Tektronix hot melt piezoelectric ink jet ♦ Any of the IJ series
Electro-static	An electric field is used to accelerate selected drops towards the print medium.	<ul style="list-style-type: none"> ♦ Low power ♦ Simple print head construction 	<ul style="list-style-type: none"> ♦ Field strength required for separation of small drops is near or above air breakdown 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ Tone-Jet
Direct magnetic field	A magnetic field is used to accelerate selected drops of magnetic ink towards the print medium.	<ul style="list-style-type: none"> ♦ Low power ♦ Simple print head construction 	<ul style="list-style-type: none"> ♦ Requires magnetic ink ♦ Requires strong magnetic field 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications
Cross magnetic field	The print head is placed in a constant magnetic field. The Lorenz force in a current carrying wire is used to move the actuator.	<ul style="list-style-type: none"> ♦ Does not require magnetic materials to be integrated in the print head manufacturing process 	<ul style="list-style-type: none"> ♦ Requires external magnet ♦ Current densities may be high, resulting in electromigration problems 	<ul style="list-style-type: none"> ♦ IJ06, IJ16

AUXILIARY MECHANISM (APPLIED TO ALL NOZZLES)				
	Description	Advantages	Disadvantages	Examples
Pulsed magnetic field	A pulsed magnetic field is used to cyclically attract a paddle, which pushes on the ink. A small actuator moves a catch, which selectively prevents the paddle from moving.	<ul style="list-style-type: none"> ♦ Very low power operation is possible ♦ Small print head size 	<ul style="list-style-type: none"> ♦ Complex print head construction ♦ Magnetic materials required in print head 	♦ IJ10

ACTUATOR AMPLIFICATION OR MODIFICATION METHOD				
	Description	Advantages	Disadvantages	Examples
None	No actuator mechanical amplification is used. The actuator directly drives the drop ejection process.	<ul style="list-style-type: none"> Operational simplicity 	<ul style="list-style-type: none"> Many actuator mechanisms have insufficient travel, or insufficient force, to efficiently drive the drop ejection process 	<ul style="list-style-type: none"> Thermal Bubble Ink jet IJ01, IJ02, IJ06, IJ07, IJ16, IJ25, IJ26
Differential expansion bend actuator	An actuator material expands more on one side than on the other. The expansion may be thermal, piezoelectric, magnetostrictive, or other mechanism. The bend actuator converts a high force low travel actuator mechanism to high travel, lower force mechanism.	<ul style="list-style-type: none"> Provides greater travel in a reduced print head area 	<ul style="list-style-type: none"> High stresses are involved Care must be taken that the materials do not delaminate Residual bend resulting from high temperature or high stress during formation 	<ul style="list-style-type: none"> Piezoelectric IJ03, IJ09, IJ17, IJ18, IJ19, IJ20, IJ21, IJ22, IJ23, IJ24, IJ27, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ35, IJ36, IJ37, IJ38, IJ39, IJ42, IJ43, IJ44
Transient bend actuator	A trilayer bend actuator where the two outside layers are identical. This cancels bend due to ambient temperature and residual stress. The actuator only responds to transient heating of one side or the other.	<ul style="list-style-type: none"> Very good temperature stability High speed, as a new drop can be fired before heat dissipates Cancels residual stress of formation 	<ul style="list-style-type: none"> High stresses are involved Care must be taken that the materials do not delaminate 	<ul style="list-style-type: none"> IJ40, IJ41
Reverse spring	The actuator loads a spring. When the actuator is turned off, the spring releases. This can reverse the force/distance curve of the actuator to make it compatible with the force/time requirements of the drop ejection.	<ul style="list-style-type: none"> Better coupling to the ink 	<ul style="list-style-type: none"> Fabrication complexity High stress in the spring 	<ul style="list-style-type: none"> IJ05, IJ11
Actuator stack	A series of thin actuators are stacked. This can be appropriate where actuators require high electric field strength, such as electrostatic and piezoelectric actuators.	<ul style="list-style-type: none"> Increased travel Reduced drive voltage 	<ul style="list-style-type: none"> Increased fabrication complexity Increased possibility of short circuits due to pinholes 	<ul style="list-style-type: none"> Some piezoelectric ink jets IJ04

ACTUATOR AMPLIFICATION OR MODIFICATION METHOD				
	Description	Advantages	Disadvantages	Examples
Multiple actuators	Multiple smaller actuators are used simultaneously to move the ink. Each actuator need provide only a portion of the force required.	<ul style="list-style-type: none"> Increases the force available from an actuator Multiple actuators can be positioned to control ink flow accurately 	<ul style="list-style-type: none"> Actuator forces may not add linearly, reducing efficiency 	<ul style="list-style-type: none"> IJ12, IJ13, IJ18, IJ20, IJ22, IJ28, IJ42, IJ43
Linear Spring	A linear spring is used to transform a motion with small travel and high force into a longer travel, lower force motion.	<ul style="list-style-type: none"> Matches low travel actuator with higher travel requirements Non-contact method of motion transformation 	<ul style="list-style-type: none"> Requires print head area for the spring 	<ul style="list-style-type: none"> IJ15
Coiled actuator	A bend actuator is coiled to provide greater travel in a reduced chip area.	<ul style="list-style-type: none"> Increases travel Reduces chip area Planar implementations are relatively easy to fabricate. 	<ul style="list-style-type: none"> Generally restricted to planar implementations due to extreme fabrication difficulty in other orientations. 	<ul style="list-style-type: none"> IJ17, IJ21, IJ34, IJ35
Flexure bend actuator	A bend actuator has a small region near the fixture point, which flexes much more readily than the remainder of the actuator. The actuator flexing is effectively converted from an even coiling to an angular bend, resulting in greater travel of the actuator tip.	<ul style="list-style-type: none"> Simple means of increasing travel of a bend actuator 	<ul style="list-style-type: none"> Care must be taken not to exceed the elastic limit in the flexure area Stress distribution is very uneven Difficult to accurately model with finite element analysis 	<ul style="list-style-type: none"> IJ10, IJ19, IJ33
Catch	The actuator controls a small catch. The catch either enables or disables movement of an ink pusher that is controlled in a bulk manner.	<ul style="list-style-type: none"> Very low actuator energy Very small actuator size 	<ul style="list-style-type: none"> Complex construction Requires external force Unsuitable for pigmented inks 	<ul style="list-style-type: none"> IJ10
Gears	Gears can be used to increase travel at the expense of duration. Circular gears, rack and pinion, ratchets, and other gearing methods can be used.	<ul style="list-style-type: none"> Low force, low travel actuators can be used Can be fabricated using standard surface MEMS processes 	<ul style="list-style-type: none"> Moving parts are required Several actuator cycles are required More complex drive electronics Complex construction Friction, friction, and wear are possible 	<ul style="list-style-type: none"> IJ13

ACTUATOR AMPLIFICATION OR MODIFICATION METHOD				
	Description	Advantages	Disadvantages	Examples
Buckle plate	A buckle plate can be used to change a slow actuator into a fast motion. It can also convert a high force, low travel actuator into a high travel, medium force motion.	<ul style="list-style-type: none"> ♦ Very fast movement achievable 	<ul style="list-style-type: none"> ♦ Must stay within elastic limits of the materials for long device life ♦ High stresses involved ♦ Generally high power requirement 	<ul style="list-style-type: none"> ♦ S. Hirata et al, "An Ink-jet Head Using Diaphragm Microactuator", Proc. IEEE MEMS, Feb. 1996, pp 418-423. ♦ IJ18, IJ27
Tapered magnetic pole	A tapered magnetic pole can increase travel at the expense of force.	<ul style="list-style-type: none"> ♦ Linearizes the magnetic force/distance curve 	<ul style="list-style-type: none"> ♦ Complex construction 	<ul style="list-style-type: none"> ♦ IJ14
Lever	A lever and fulcrum is used to transform a motion with small travel and high force into a motion with longer travel and lower force. The lever can also reverse the direction of travel.	<ul style="list-style-type: none"> ♦ Matches low travel actuator with higher travel requirements ♦ Fulcrum area has no linear movement, and can be used for a fluid seal 	<ul style="list-style-type: none"> ♦ High stress around the fulcrum 	<ul style="list-style-type: none"> ♦ IJ32, IJ36, IJ37
Rotary impeller	The actuator is connected to a rotary impeller. A small angular deflection of the actuator results in a rotation of the impeller vanes, which push the ink against stationary vanes and out of the nozzle.	<ul style="list-style-type: none"> ♦ High mechanical advantage ♦ The ratio of force to travel of the actuator can be matched to the nozzle requirements by varying the number of impeller vanes 	<ul style="list-style-type: none"> ♦ Complex construction ♦ Unsuitable for pigmented inks 	<ul style="list-style-type: none"> ♦ IJ28
Acoustic lens	A refractive or diffractive (e.g. zone plate) acoustic lens is used to concentrate sound waves.	<ul style="list-style-type: none"> ♦ No moving parts 	<ul style="list-style-type: none"> ♦ Large area required ♦ Only relevant for acoustic ink jets 	<ul style="list-style-type: none"> ♦ 1993 Hadimioglu et al, EUP 550,192 ♦ 1993 Elrod et al, EUP 572,220
Sharp conductive point	A sharp point is used to concentrate an electrostatic field.	<ul style="list-style-type: none"> ♦ Simple construction 	<ul style="list-style-type: none"> ♦ Difficult to fabricate using standard VLSI processes for a surface ejecting ink-jet ♦ Only relevant for electrostatic ink jets 	<ul style="list-style-type: none"> ♦ Tone-jet

ACTUATOR MOTION				
	Description	Advantages	Disadvantages	Examples
Volume expansion	The volume of the actuator changes, pushing the ink in all directions.	<ul style="list-style-type: none"> Simple construction in the case of thermal ink jet 	<ul style="list-style-type: none"> High energy is typically required to achieve volume expansion. This leads to thermal stress, cavitation, and kagation in thermal ink jet implementations 	<ul style="list-style-type: none"> Hewlett-Packard Thermal Ink jet Canon Bubblejet
Linear, normal to chip surface	The actuator moves in a direction normal to the print head surface. The nozzle is typically in the line of movement.	<ul style="list-style-type: none"> Efficient coupling to ink drops ejected normal to the surface 	<ul style="list-style-type: none"> High fabrication complexity may be required to achieve perpendicular motion 	<ul style="list-style-type: none"> IJ01, IJ02, IJ04, IJ07, IJ11, IJ14
Parallel to chip surface	The actuator moves parallel to the print head surface. Drop ejection may still be normal to the surface.	<ul style="list-style-type: none"> Suitable for planar fabrication 	<ul style="list-style-type: none"> Fabrication complexity Friction Stiction 	<ul style="list-style-type: none"> IJ12, IJ13, IJ15, IJ33, IJ34, IJ35, IJ36
Membrane push	An actuator with a high force but small area is used to push a stiff membrane that is in contact with the ink.	<ul style="list-style-type: none"> The effective area of the actuator becomes the membrane area 	<ul style="list-style-type: none"> Fabrication complexity Actuator size Difficulty of integration in a VLSI process 	<ul style="list-style-type: none"> 1982 Howkins USP 4,459,601
Rotary	The actuator causes the rotation of some element, such a grill or impeller	<ul style="list-style-type: none"> Rotary levers may be used to increase travel Small chip area requirements 	<ul style="list-style-type: none"> Device complexity May have friction at a pivot point 	<ul style="list-style-type: none"> IJ05, IJ08, IJ13, IJ28
Bend	The actuator bends when energized. This may be due to differential thermal expansion, piezoelectric expansion, magnetostriction, or other form of relative dimensional change.	<ul style="list-style-type: none"> A very small change in dimensions can be converted to a large motion. 	<ul style="list-style-type: none"> Requires the actuator to be made from at least two distinct layers, or to have a thermal difference across the actuator 	<ul style="list-style-type: none"> 1970 Kyser et al USP 3,946,398 1973 Stemme USP 3,747,120 IJ03, IJ09, IJ10, IJ19, IJ23, IJ24, IJ25, IJ29, IJ30, IJ31, IJ33, IJ34, IJ35
Swivel	The actuator swivels around a central pivot. This motion is suitable where there are opposite forces applied to opposite sides of the paddle, e.g. Lorenz force.	<ul style="list-style-type: none"> Allows operation where the net linear force on the paddle is zero Small chip area requirements 	<ul style="list-style-type: none"> Inefficient coupling to the ink motion 	<ul style="list-style-type: none"> IJ06
Straighten	The actuator is normally bent, and straightens when energized.	<ul style="list-style-type: none"> Can be used with shape memory alloys where the austenitic phase is planar 	<ul style="list-style-type: none"> Requires careful balance of stresses to ensure that the quiescent bend is accurate 	<ul style="list-style-type: none"> IJ26, IJ32

ACTUATOR MOTION				
	Description	Advantages	Disadvantages	Examples
Double bend	The actuator bends in one direction when one element is energized, and bends the other way when another element is energized.	<ul style="list-style-type: none"> ♦ One actuator can be used to power two nozzles. ♦ Reduced chip size. ♦ Not sensitive to ambient temperature 	<ul style="list-style-type: none"> ♦ Difficult to make the drops ejected by both bend directions identical. ♦ A small efficiency loss compared to equivalent single bend actuators. 	♦ IJ36, IJ37, IJ38
Shear	Energizing the actuator causes a shear motion in the actuator material.	<ul style="list-style-type: none"> ♦ Can increase the effective travel of piezoelectric actuators 	<ul style="list-style-type: none"> ♦ Not readily applicable to other actuator mechanisms 	♦ 1985 Fishbeck USP 4,584,590
Radial constriction	The actuator squeezes an ink reservoir, forcing ink from a constricted nozzle.	<ul style="list-style-type: none"> ♦ Relatively easy to fabricate single nozzles from glass tubing as macroscopic structures 	<ul style="list-style-type: none"> ♦ High force required ♦ Inefficient ♦ Difficult to integrate with VLSI processes 	♦ 1970 Zoltan USP 3,683,212
Coil / uncoil	A coiled actuator uncoils or coils more tightly. The motion of the free end of the actuator ejects the ink.	<ul style="list-style-type: none"> ♦ Easy to fabricate as a planar VLSI process ♦ Small area required, therefore low cost 	<ul style="list-style-type: none"> ♦ Difficult to fabricate for non-planar devices ♦ Poor out-of-plane stiffness 	♦ IJ17, IJ21, IJ34, IJ35
Bow	The actuator bows (or buckles) in the middle when energized.	<ul style="list-style-type: none"> ♦ Can increase the speed of travel ♦ Mechanically rigid 	<ul style="list-style-type: none"> ♦ Maximum travel is constrained ♦ High force required 	♦ IJ16, IJ18, IJ27
Push-Pull	Two actuators control a shutter. One actuator pulls the shutter, and the other pushes it.	<ul style="list-style-type: none"> ♦ The structure is pinned at both ends, so has a high out-of-plane rigidity 	<ul style="list-style-type: none"> ♦ Not readily suitable for ink jets which directly push the ink 	♦ IJ18
Curl inwards	A set of actuators curl inwards to reduce the volume of ink that they enclose.	<ul style="list-style-type: none"> ♦ Good fluid flow to the region behind the actuator increases efficiency 	<ul style="list-style-type: none"> ♦ Design complexity 	♦ IJ20, IJ42
Curl outwards	A set of actuators curl outwards, pressurizing ink in a chamber surrounding the actuators, and expelling ink from a nozzle in the chamber.	<ul style="list-style-type: none"> ♦ Relatively simple construction 	<ul style="list-style-type: none"> ♦ Relatively large chip area 	♦ IJ43
Iris	Multiple vanes enclose a volume of ink. These simultaneously rotate, reducing the volume between the vanes.	<ul style="list-style-type: none"> ♦ High efficiency ♦ Small chip area 	<ul style="list-style-type: none"> ♦ High fabrication complexity ♦ Not suitable for pigmented inks 	♦ IJ22

ACTUATOR MOTION				
	Description	Advantages	Disadvantages	Examples
Acoustic vibration	The actuator vibrates at a high frequency.	<ul style="list-style-type: none"> ♦ The actuator can be physically distant from the ink 	<ul style="list-style-type: none"> ♦ Large area required for efficient operation at useful frequencies ♦ Acoustic coupling and crosstalk ♦ Complex drive circuitry ♦ Poor control of drop volume and position 	<ul style="list-style-type: none"> ♦ 1993 Hadimioglu et al, EUP 550,192 ♦ 1993 Elrod et al, EUP 572,220
None	In various ink jet designs the actuator does not move.	<ul style="list-style-type: none"> ♦ No moving parts 	<ul style="list-style-type: none"> ♦ Various other tradeoffs are required to eliminate moving parts 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ Tone-jet

NOZZLE REFILL METHOD				
	Description	Advantages	Disadvantages	Examples
Surface tension	This is the normal way that ink jets are refilled. After the actuator is energized, it typically returns rapidly to its normal position. This rapid return sucks in air through the nozzle opening. The ink surface tension at the nozzle then exerts a small force restoring the meniscus to a minimum area. This force refills the nozzle.	<ul style="list-style-type: none"> ◆ Fabrication simplicity ◆ Operational simplicity 	<ul style="list-style-type: none"> ◆ Low speed ◆ Surface tension force relatively small compared to actuator force ◆ Long refill time usually dominates the total repetition rate 	<ul style="list-style-type: none"> ◆ Thermal ink jet ◆ Piezoelectric ink jet ◆ IJ01-IJ07, IJ10-IJ14, IJ16, IJ20, IJ22-IJ45
Shuttered oscillating ink pressure	Ink to the nozzle chamber is provided at a pressure that oscillates at twice the drop ejection frequency. When a drop is to be ejected, the shutter is opened for 3 half cycles: drop ejection, actuator return, and refill. The shutter is then closed to prevent the nozzle chamber emptying during the next negative pressure cycle.	<ul style="list-style-type: none"> ◆ High speed ◆ Low actuator energy, as the actuator need only open or close the shutter, instead of ejecting the ink drop 	<ul style="list-style-type: none"> ◆ Requires common ink pressure oscillator ◆ May not be suitable for pigmented inks 	<ul style="list-style-type: none"> ◆ IJ08, IJ13, IJ15, IJ17, IJ18, IJ19, IJ21
Refill actuator	After the main actuator has ejected a drop a second (refill) actuator is energized. The refill actuator pushes ink into the nozzle chamber. The refill actuator returns slowly, to prevent its return from emptying the chamber again.	<ul style="list-style-type: none"> ◆ High speed, as the nozzle is actively refilled 	<ul style="list-style-type: none"> ◆ Requires two independent actuators per nozzle 	<ul style="list-style-type: none"> ◆ IJ09
Positive ink pressure	The ink is held a slight positive pressure. After the ink drop is ejected, the nozzle chamber fills quickly as surface tension and ink pressure both operate to refill the nozzle.	<ul style="list-style-type: none"> ◆ High refill rate, therefore a high drop repetition rate is possible 	<ul style="list-style-type: none"> ◆ Surface spill must be prevented ◆ Highly hydrophobic print head surfaces are required 	<ul style="list-style-type: none"> ◆ Silverbrook, EP 0771 658 A2 and related patent applications ◆ Alternative for: IJ01-IJ07, IJ10-IJ14, IJ16, IJ20, IJ22-IJ45

METHOD OF RESTRICTING BACK-FLOW THROUGH INLET				
	Description	Advantages	Disadvantages	Examples
Long inlet channel	The ink inlet channel to the nozzle chamber is made long and relatively narrow, relying on viscous drag to reduce inlet back-flow.	<ul style="list-style-type: none"> ◆ Design simplicity ◆ Operational simplicity ◆ Reduces crosstalk 	<ul style="list-style-type: none"> ◆ Restricts refill rate ◆ May result in a relatively large chip area ◆ Only partially effective 	<ul style="list-style-type: none"> ◆ Thermal ink jet ◆ Piezoelectric ink jet ◆ IJ42, IJ43
Positive ink pressure	The ink is under a positive pressure, so that in the quiescent state some of the ink drop already protrudes from the nozzle. This reduces the pressure in the nozzle chamber which is required to eject a certain volume of ink. The reduction in chamber pressure results in a reduction in ink pushed out through the inlet.	<ul style="list-style-type: none"> ◆ Drop selection and separation forces can be reduced ◆ Fast refill time 	<ul style="list-style-type: none"> ◆ Requires a method (such as a nozzle rim or effective hydrophobizing, or both) to prevent flooding of the ejection surface of the print head. 	<ul style="list-style-type: none"> ◆ Silverbrook, EP 0771 658 A2 and related patent applications ◆ Possible operation of the following: IJ01-IJ07, IJ09- IJ12, IJ14, IJ16, IJ20, IJ22, , IJ23-IJ34, IJ36- IJ41, IJ44
Baffle	One or more baffles are placed in the inlet ink flow. When the actuator is energized, the rapid ink movement creates eddies which restrict the flow through the inlet. The slower refill process is unrestricted, and does not result in eddies.	<ul style="list-style-type: none"> ◆ The refill rate is not as restricted as the long inlet method. ◆ Reduces crosstalk 	<ul style="list-style-type: none"> ◆ Design complexity ◆ May increase fabrication complexity (e.g. Tektronix hot melt Piezoelectric print heads). 	<ul style="list-style-type: none"> ◆ HP Thermal Ink Jet ◆ Tektronix piezoelectric ink jet
Flexible flap restricts inlet	In this method recently disclosed by Canon, the expanding actuator (bubble) pushes on a flexible flap that restricts the inlet.	<ul style="list-style-type: none"> ◆ Significantly reduces back-flow for edge-shooter thermal ink jet devices 	<ul style="list-style-type: none"> ◆ Not applicable to most ink jet configurations ◆ Increased fabrication complexity ◆ Inelastic deformation of polymer flap results in creep over extended use 	<ul style="list-style-type: none"> ◆ Canon

METHOD OF RESTRICTING BACK-FLOW THROUGH INLET				
	Description	Advantages	Disadvantages	Examples
Inlet filter	A filter is located between the ink inlet and the nozzle chamber. The filter has a multitude of small holes or slots, restricting ink flow. The filter also removes particles which may block the nozzle.	<ul style="list-style-type: none"> ♦ Additional advantage of ink filtration ♦ Ink filter may be fabricated with no additional process steps 	<ul style="list-style-type: none"> ♦ Restricts refill rate ♦ May result in complex construction 	♦ IJ04, IJ12, IJ24, IJ27, IJ29, IJ30
Small inlet compared to nozzle	The ink inlet channel to the nozzle chamber has a substantially smaller cross section than that of the nozzle, resulting in easier ink egress out of the nozzle than out of the inlet.	♦ Design simplicity	<ul style="list-style-type: none"> ♦ Restricts refill rate ♦ May result in a relatively large chip area ♦ Only partially effective 	♦ IJ02, IJ37, IJ44
Inlet shutter	A secondary actuator controls the position of a shutter, closing off the ink inlet when the main actuator is energized.	♦ Increases speed of the ink-jet print head operation	♦ Requires separate refill actuator and drive circuit	♦ IJ09
The inlet is located behind the ink-pushing surface	The method avoids the problem of inlet back-flow by arranging the ink-pushing surface of the actuator between the inlet and the nozzle.	♦ Back-flow problem is eliminated	♦ Requires careful design to minimize the negative pressure behind the paddle	♦ IJ01, IJ03, IJ05, IJ06, IJ07, IJ10, IJ11, IJ14, IJ16, IJ22, IJ23, IJ25, IJ28, IJ31, IJ32, IJ33, IJ34, IJ35, IJ36, IJ39, IJ40, IJ41
Part of the actuator moves to shut off the inlet	The actuator and a wall of the ink chamber are arranged so that the motion of the actuator closes off the inlet.	<ul style="list-style-type: none"> ♦ Significant reductions in back-flow can be achieved ♦ Compact designs possible 	♦ Small increase in fabrication complexity	♦ IJ07, IJ20, IJ26, IJ38
Nozzle actuator does not result in ink back-flow	In some configurations of ink jet, there is no expansion or movement of an actuator which may cause ink back-flow through the inlet.	♦ Ink back-flow problem is eliminated	♦ None related to ink back-flow on actuation	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ Valve-jet ♦ Tone-jet

NOZZLE CLEARING METHOD				
	Description	Advantages	Disadvantages	Examples
Normal nozzle firing	<p>All of the nozzles are fired periodically, before the ink has a chance to dry. When not in use the nozzles are sealed (capped) against air.</p> <p>The nozzle firing is usually performed during a special clearing cycle, after first moving the print head to a cleaning station.</p>	<ul style="list-style-type: none"> ◆ No added complexity on the print head 	<ul style="list-style-type: none"> ◆ May not be sufficient to displace dried ink 	<ul style="list-style-type: none"> ◆ Most ink jet systems ◆ IJ01, IJ02, IJ03, IJ04, IJ05, IJ06, IJ07, IJ09, IJ10, IJ11, IJ12, IJ14, IJ16, IJ20, IJ22, IJ23, IJ24, IJ25, IJ26, IJ27, IJ28, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ36, IJ37, IJ38, IJ39, IJ40,, IJ41, IJ42, IJ43, IJ44,, IJ45
Extra power to ink heater	<p>In systems which heat the ink, but do not boil it under normal situations, nozzle clearing can be achieved by over-powering the heater and boiling ink at the nozzle.</p>	<ul style="list-style-type: none"> ◆ Can be highly effective if the heater is adjacent to the nozzle 	<ul style="list-style-type: none"> ◆ Requires higher drive voltage for clearing ◆ May require larger drive transistors 	<ul style="list-style-type: none"> ◆ Silverbrook, EP 0771 658 A2 and related patent applications
Rapid succession of actuator pulses	<p>The actuator is fired in rapid succession. In some configurations, this may cause heat build-up at the nozzle which boils the ink, clearing the nozzle. In other situations, it may cause sufficient vibrations to dislodge clogged nozzles.</p>	<ul style="list-style-type: none"> ◆ Does not require extra drive circuits on the print head ◆ Can be readily controlled and initiated by digital logic 	<ul style="list-style-type: none"> ◆ Effectiveness depends substantially upon the configuration of the ink jet nozzle 	<ul style="list-style-type: none"> ◆ May be used with: IJ01, IJ02, IJ03, IJ04, IJ05, IJ06, IJ07, IJ09, IJ10, IJ11, IJ14, IJ16, IJ20, IJ22, IJ23, IJ24, IJ25, IJ27, IJ28, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ36, IJ37, IJ38, IJ39, IJ40, IJ41, IJ42, IJ43, IJ44, IJ45
Extra power to ink pushing actuator	<p>Where an actuator is not normally driven to the limit of its motion, nozzle clearing may be assisted by providing an enhanced drive signal to the actuator.</p>	<ul style="list-style-type: none"> ◆ A simple solution where applicable 	<ul style="list-style-type: none"> ◆ Not suitable where there is a hard limit to actuator movement 	<ul style="list-style-type: none"> ◆ May be used with: IJ03, IJ09, IJ16, IJ20, IJ23, IJ24, IJ25, IJ27, IJ29, IJ30, IJ31, IJ32, IJ39, IJ40, IJ41, IJ42, IJ43, IJ44, IJ45

NOZZLE CLEARING METHOD				
	Description	Advantages	Disadvantages	Examples
Acoustic resonance	An ultrasonic wave is applied to the ink chamber. This wave is of an appropriate amplitude and frequency to cause sufficient force at the nozzle to clear blockages. This is easiest to achieve if the ultrasonic wave is at a resonant frequency of the ink cavity.	<ul style="list-style-type: none"> ♦ A high nozzle clearing capability can be achieved ♦ May be implemented at very low cost in systems which already include acoustic actuators 	<ul style="list-style-type: none"> ♦ High implementation cost if system does not already include an acoustic actuator 	<ul style="list-style-type: none"> ♦ IJ08, IJ13, IJ15, IJ17, IJ18, IJ19, IJ21
Nozzle clearing plate	A microfabricated plate is pushed against the nozzles. The plate has a post for every nozzle. A post moves through each nozzle, displacing dried ink.	<ul style="list-style-type: none"> ♦ Can clear severely clogged nozzles 	<ul style="list-style-type: none"> ♦ Accurate mechanical alignment is required ♦ Moving parts are required ♦ There is risk of damage to the nozzles ♦ Accurate fabrication is required 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications
Ink pressure pulse	The pressure of the ink is temporarily increased so that ink streams from all of the nozzles. This may be used in conjunction with actuator energizing.	<ul style="list-style-type: none"> ♦ May be effective where other methods cannot be used 	<ul style="list-style-type: none"> ♦ Requires pressure pump or other pressure actuator ♦ Expensive ♦ Wasteful of ink 	<ul style="list-style-type: none"> ♦ May be used with all IJ series ink jets
Print head wiper	A flexible 'blade' is wiped across the print head surface. The blade is usually fabricated from a flexible polymer, e.g. rubber or synthetic elastomer.	<ul style="list-style-type: none"> ♦ Effective for planar print head surfaces ♦ Low cost 	<ul style="list-style-type: none"> ♦ Difficult to use if print head surface is non-planar or very fragile ♦ Requires mechanical parts ♦ Blade can wear out in high volume print systems 	<ul style="list-style-type: none"> ♦ Many ink jet systems
Separate ink boiling heater	A separate heater is provided at the nozzle although the normal drop ejection mechanism does not require it. The heaters do not require individual drive circuits, as many nozzles can be cleared simultaneously, and no imaging is required.	<ul style="list-style-type: none"> ♦ Can be effective where other nozzle clearing methods cannot be used ♦ Can be implemented at no additional cost in some ink jet configurations 	<ul style="list-style-type: none"> ♦ Fabrication complexity 	<ul style="list-style-type: none"> ♦ Can be used with many IJ series ink jets

NOZZLE CLEARING METHOD				
	Description	Advantages	Disadvantages	Examples
NOZZLE PLATE CONSTRUCTION				
	Description	Advantages	Disadvantages	Examples
Electro-formed nickel	A nozzle plate is separately fabricated from electroformed nickel, and bonded to the print head chip.	<ul style="list-style-type: none"> ◆ Fabrication simplicity 	<ul style="list-style-type: none"> ◆ High temperatures and pressures are required to bond nozzle plate ◆ Minimum thickness constraints ◆ Differential thermal expansion 	<ul style="list-style-type: none"> ◆ Hewlett Packard Thermal Ink jet
Laser ablated or drilled polymer	Individual nozzle holes are ablated by an intense UV laser in a nozzle plate, which is typically a polymer such as polyimide or polysulphone	<ul style="list-style-type: none"> ◆ No masks required ◆ Can be quite fast ◆ Some control over nozzle profile is possible ◆ Equipment required is relatively low cost 	<ul style="list-style-type: none"> ◆ Each hole must be individually formed ◆ Special equipment required ◆ Slow where there are many thousands of nozzles per print head ◆ May produce thin burrs at exit holes 	<ul style="list-style-type: none"> ◆ Canon Bubblejet ◆ 1988 Sercel et al., SPIE, Vol. 998 Excimer Beam Applications, pp. 76-83 ◆ 1993 Watanabe et al., USP 5,208,604
Silicon micro-machined	A separate nozzle plate is micromachined from single crystal silicon, and bonded to the print head wafer.	<ul style="list-style-type: none"> ◆ High accuracy is attainable 	<ul style="list-style-type: none"> ◆ Two part construction ◆ High cost ◆ Requires precision alignment ◆ Nozzles may be clogged by adhesive 	<ul style="list-style-type: none"> ◆ K. Bean, IEEE Transactions on Electron Devices, Vol. ED-25, No. 10, 1978, pp 1185-1195 ◆ Xerox 1990 Hawkins et al., USP 4,899,181
Glass capillaries	Fine glass capillaries are drawn from glass tubing. This method has been used for making individual nozzles, but is difficult to use for bulk manufacturing of print heads with thousands of nozzles.	<ul style="list-style-type: none"> ◆ No expensive equipment required ◆ Simple to make single nozzles 	<ul style="list-style-type: none"> ◆ Very small nozzle sizes are difficult to form ◆ Not suited for mass production 	<ul style="list-style-type: none"> ◆ 1970 Zoltan USP 3,683,212
Monolithic, surface micro-machined using VLSI lithographic processes	The nozzle plate is deposited as a layer using standard VLSI deposition techniques. Nozzles are etched in the nozzle plate using VLSI lithography and etching.	<ul style="list-style-type: none"> ◆ High accuracy (<1 μm) ◆ Monolithic ◆ Low cost ◆ Existing processes can be used 	<ul style="list-style-type: none"> ◆ Requires sacrificial layer under the nozzle plate to form the nozzle chamber ◆ Surface may be fragile to the touch 	<ul style="list-style-type: none"> ◆ Silverbrook, EP 0771 658 A2 and related patent applications ◆ IJ01, IJ02, IJ04, IJ11, IJ12, IJ17, IJ18, IJ20, IJ22, IJ24, IJ27, IJ28, IJ29, IJ30, IJ31, IJ32, IJ33, IJ34, IJ36, IJ37, IJ38, IJ39, IJ40, IJ41, IJ42, IJ43, IJ44

NOZZLE CLEARING METHOD				
	Description	Advantages	Disadvantages	Examples
Monolithic, etched through substrate	The nozzle plate is a buried etch stop in the wafer. Nozzle chambers are etched in the front of the wafer, and the wafer is thinned from the back side. Nozzles are then etched in the etch stop layer.	<ul style="list-style-type: none"> ♦ High accuracy (<1 μm) ♦ Monolithic ♦ Low cost ♦ No differential expansion 	<ul style="list-style-type: none"> ♦ Requires long etch times ♦ Requires a support wafer 	<ul style="list-style-type: none"> ♦ IJ03, IJ05, IJ06, IJ07, IJ08, IJ09, IJ10, IJ13, IJ14, IJ15, IJ16, IJ19, IJ21, IJ23, IJ25, IJ26
No nozzle plate	Various methods have been tried to eliminate the nozzles entirely, to prevent nozzle clogging. These include thermal bubble mechanisms and acoustic lens mechanisms	<ul style="list-style-type: none"> ♦ No nozzles to become clogged 	<ul style="list-style-type: none"> ♦ Difficult to control drop position accurately ♦ Crosstalk problems 	<ul style="list-style-type: none"> ♦ Ricoh 1995 Sekiya et al USP 5,412,413 ♦ 1993 Hadimioglu et al EUP 550,192 ♦ 1993 Elrod et al EUP 572,220
Trough	Each drop ejector has a trough through which a paddle moves. There is no nozzle plate.	<ul style="list-style-type: none"> ♦ Reduced manufacturing complexity ♦ Monolithic 	<ul style="list-style-type: none"> ♦ Drop firing direction is sensitive to wicking. 	<ul style="list-style-type: none"> ♦ IJ35
Nozzle slit instead of individual nozzles	The elimination of nozzle holes and replacement by a slit encompassing many actuator positions reduces nozzle clogging, but increases crosstalk due to ink surface waves	<ul style="list-style-type: none"> ♦ No nozzles to become clogged 	<ul style="list-style-type: none"> ♦ Difficult to control drop position accurately ♦ Crosstalk problems 	<ul style="list-style-type: none"> ♦ 1989 Saito et al USP 4,799,068

DROP EJECTION DIRECTION				
	Description	Advantages	Disadvantages	Examples
Edge ('edge shooter')	Ink flow is along the surface of the chip, and ink drops are ejected from the chip edge.	<ul style="list-style-type: none"> ♦ Simple construction ♦ No silicon etching required ♦ Good heat sinking via substrate ♦ Mechanically strong ♦ Ease of chip handling 	<ul style="list-style-type: none"> ♦ Nozzles limited to edge ♦ High resolution is difficult ♦ Fast color printing requires one print head per color 	<ul style="list-style-type: none"> ♦ Canon Bubblejet 1979 Endo et al GB patent 2,007,162 ♦ Xerox heater-in-pit 1990 Hawkins et al USP 4,899,181 ♦ Tone-jet
Surface ('roof shooter')	Ink flow is along the surface of the chip, and ink drops are ejected from the chip surface, normal to the plane of the chip.	<ul style="list-style-type: none"> ♦ No bulk silicon etching required ♦ Silicon can make an effective heat sink ♦ Mechanical strength 	<ul style="list-style-type: none"> ♦ Maximum ink flow is severely restricted 	<ul style="list-style-type: none"> ♦ Hewlett-Packard TIJ 1982 Vaught et al USP 4,490,728 ♦ IJ02, IJ11, IJ12, IJ20, IJ22

DROP EJECTION DIRECTION				
	Description	Advantages	Disadvantages	Examples
Through chip, forward ('up shooter')	Ink flow is through the chip, and ink drops are ejected from the front surface of the chip.	<ul style="list-style-type: none"> ♦ High ink flow ♦ Suitable for pagewidth print heads ♦ High nozzle packing density therefore low manufacturing cost 	<ul style="list-style-type: none"> ♦ Requires bulk silicon etching 	<ul style="list-style-type: none"> ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ IJ04, IJ17, IJ18, IJ24, IJ27-IJ45
Through chip, reverse ('down shooter')	Ink flow is through the chip, and ink drops are ejected from the rear surface of the chip.	<ul style="list-style-type: none"> ♦ High ink flow ♦ Suitable for pagewidth print heads ♦ High nozzle packing density therefore low manufacturing cost 	<ul style="list-style-type: none"> ♦ Requires wafer thinning ♦ Requires special handling during manufacture 	<ul style="list-style-type: none"> ♦ IJ01, IJ03, IJ05, IJ06, IJ07, IJ08, IJ09, IJ10, IJ13, IJ14, IJ15, IJ16, IJ19, IJ21, IJ23, IJ25, IJ26
Through actuator	Ink flow is through the actuator, which is not fabricated as part of the same substrate as the drive transistors.	<ul style="list-style-type: none"> ♦ Suitable for piezoelectric print heads 	<ul style="list-style-type: none"> ♦ Pagewidth print heads require several thousand connections to drive circuits ♦ Cannot be manufactured in standard CMOS fabs ♦ Complex assembly required 	<ul style="list-style-type: none"> ♦ Epson Stylus ♦ Tektronix hot melt piezoelectric ink jets

INK TYPE				
	Description	Advantages	Disadvantages	Examples
Aqueous, dye	Water based ink which typically contains: water, dye, surfactant, humectant, and biocide. Modern ink dyes have high water-fastness, light fastness	<ul style="list-style-type: none"> ♦ Environmentally friendly ♦ No odor 	<ul style="list-style-type: none"> ♦ Slow drying ♦ Corrosive ♦ Bleeds on paper ♦ May strikethrough ♦ Cockles paper 	<ul style="list-style-type: none"> ♦ Most existing ink jets ♦ All IJ series ink jets ♦ Silverbrook, EP 0771 658 A2 and related patent applications
Aqueous, pigment	Water based ink which typically contains: water, pigment, surfactant, humectant, and biocide. Pigments have an advantage in reduced bleed, wicking and strikethrough.	<ul style="list-style-type: none"> ♦ Environmentally friendly ♦ No odor ♦ Reduced bleed ♦ Reduced wicking ♦ Reduced strikethrough 	<ul style="list-style-type: none"> ♦ Slow drying ♦ Corrosive ♦ Pigment may clog nozzles ♦ Pigment may clog actuator mechanisms ♦ Cockles paper 	<ul style="list-style-type: none"> ♦ IJ02, IJ04, IJ21, IJ26, IJ27, IJ30 ♦ Silverbrook, EP 0771 658 A2 and related patent applications ♦ Piezoelectric ink-jets ♦ Thermal ink jets (with significant restrictions)
Methyl Ethyl Ketone (MEK)	MEK is a highly volatile solvent used for industrial printing on difficult surfaces such as aluminum cans.	<ul style="list-style-type: none"> ♦ Very fast drying ♦ Prints on various substrates such as metals and plastics 	<ul style="list-style-type: none"> ♦ Odorous ♦ Flammable 	<ul style="list-style-type: none"> ♦ All IJ series ink jets
Alcohol (ethanol, 2-butanol, and others)	Alcohol based inks can be used where the printer must operate at temperatures below the freezing point of water. An example of this is in-camera consumer photographic printing.	<ul style="list-style-type: none"> ♦ Fast drying ♦ Operates at sub-freezing temperatures ♦ Reduced paper cockle ♦ Low cost 	<ul style="list-style-type: none"> ♦ Slight odor ♦ Flammable 	<ul style="list-style-type: none"> ♦ All IJ series ink jets
Phase change (hot melt)	The ink is solid at room temperature, and is melted in the print head before jetting. Hot melt inks are usually wax based, with a melting point around 80 °C. After jetting the ink freezes almost instantly upon contacting the print medium or a transfer roller.	<ul style="list-style-type: none"> ♦ No drying time-ink instantly freezes on the print medium ♦ Almost any print medium can be used ♦ No paper cockle occurs ♦ No wicking occurs ♦ No bleed occurs ♦ No strikethrough occurs 	<ul style="list-style-type: none"> ♦ High viscosity ♦ Printed ink typically has a 'waxy' feel ♦ Printed pages may 'block' ♦ Ink temperature may be above the curie point of permanent magnets ♦ Ink heaters consume power ♦ Long warm-up time 	<ul style="list-style-type: none"> ♦ Tektronix hot melt piezoelectric ink jets ♦ 1989 Nowak USP 4,820,346 ♦ All IJ series ink jets

INK TYPE				
	Description	Advantages	Disadvantages	Examples
Oil	Oil based inks are extensively used in offset printing. They have advantages in improved characteristics on paper (especially no wicking or cockle). Oil soluble dyes and pigments are required.	<ul style="list-style-type: none"> ♦ High solubility medium for some dyes ♦ Does not cockle paper ♦ Does not wick through paper 	<ul style="list-style-type: none"> ♦ High viscosity: this is a significant limitation for use in ink jets, which usually require a low viscosity. Some short chain and multi-branched oils have a sufficiently low viscosity. ♦ Slow drying 	<ul style="list-style-type: none"> ♦ All IJ series ink jets
Micro-emulsion	A microemulsion is a stable, self forming emulsion of oil, water, and surfactant. The characteristic drop size is less than 100 nm, and is determined by the preferred curvature of the surfactant.	<ul style="list-style-type: none"> ♦ Stops ink bleed ♦ High dye solubility ♦ Water, oil, and amphiphilic soluble dyes can be used ♦ Can stabilize pigment suspensions 	<ul style="list-style-type: none"> ♦ Viscosity higher than water ♦ Cost is slightly higher than water based ink ♦ High surfactant concentration required (around 5%) 	<ul style="list-style-type: none"> ♦ All IJ series ink jets

I CLAIM

5 1. A camera system for recording images, said camera system comprising:
an electronic image sensor for sensing an image;
a digital processing means for processing said sensed image in accordance with
predetermined processing requirements;

a photo width ink jet printer means for printing said processed image on a
surface of ink jet print media, said print media including a magnetic recording surface;

10 a magnetic recording means for recording associated information on said
magnetic recording surface.

2. A camera system as claimed in claim 1 wherein said associated information
comprises audio information associated with said sensed image.

15 3. A camera system as claimed in claim 1 wherein the printer means prints said
sensed image on a first surface of said print media and the magnetic recording means
records said associated information on a second surface of said print media.

20 4. A camera system as claimed in claim 1 wherein said print media is stored on an
internal detachable roll in said camera system, said camera system comprising a hand held
portable camera device, said photo width ink jet printer being built into said hand held
portable camera device.

5. A camera system as claimed in claim 3 wherein said first and said second
surfaces are on different faces of said print media.

25

ABSTRACT

A camera provides a photo 7 printed on print media via printer device 6 under the control of a central processor 4. The photo 7 is a print of an image 5 provided by a CCD
5 sensor 3. The photo 7 includes print media having, in addition, a magnetically recordable medium whereby sound processed by sound chip 10 received from sound microphone 13 and/or processed by central processor 4 can be recorded with magnetic recording head 16 on the photo 7. The photo 7 is printed using an ink jet printer on suitable ink jet compatible print media preferably with the magnetically recordable medium on the rear of the photo 7
10 and the image 2 on the front surface of the photo 7.

Please type a plus sign (+) inside this box → ☐

PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0851-0032
Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63) <input checked="" type="checkbox"/> Declaration Submitted with Initial Filing OR <input type="checkbox"/> Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)	Attorney Docket Number	BAL20US
	First Named Inventor	KIA SILVERBROOK
	COMPLETE IF KNOWN	
	Application Number	/
	Filing Date	
	Group Art Unit	
	Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Photographic Prints Having Magnetically Recordable Media

the specification of which (Title of the Invention)
☒ is attached hereto
OR
☐ was filed on (MM/DD/YYYY) as United States Application Number or PCT International Application Number and was amended on (MM/DD/YYYY) (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
				YES	NO
PO9402	Australia	09/23/1997	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
PO7991	Australia	07/15/1997	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)
<input type="text"/>	<input type="text"/>

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

[Page 1 of 2]

Burden Hour Statement. This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

Please type a plus sign (+) inside this box → ☐

PTO/SB/01 (12-97)
 Approved for use through 9/30/00. OMB 0651-0032
 Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT International application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

☐ Customer Number → Place Customer Number Bar Code Label here
 OR
☐ Registered practitioner(s) name/registration number listed below


Name	Registration Number	Name	Registration Number

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto

Direct all correspondence to: ☒ Customer Number or Bar Code Label OR ☐ Correspondence address below

Name	Kia Silverbrook				
Address	Silverbrook Research Pty Ltd				
Address	393 Darling Street				
City	Balmain	State	NSW	ZIP	2041
Country	Australia	Telephone	61-2-9818-6633	Fax	61-2-9818-6711

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
KIA		SILVERBROOK	
Inventor's Signature		Date	June 21, 2002
Residence: City	Balmain	State	NSW
		Country	Australia
Post Office Address	393 Darling Street		
Post Office Address			
City	Balmain	State	NSW
		ZIP	2041
		Country	Australia

☐ Additional inventors are being named on the _____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

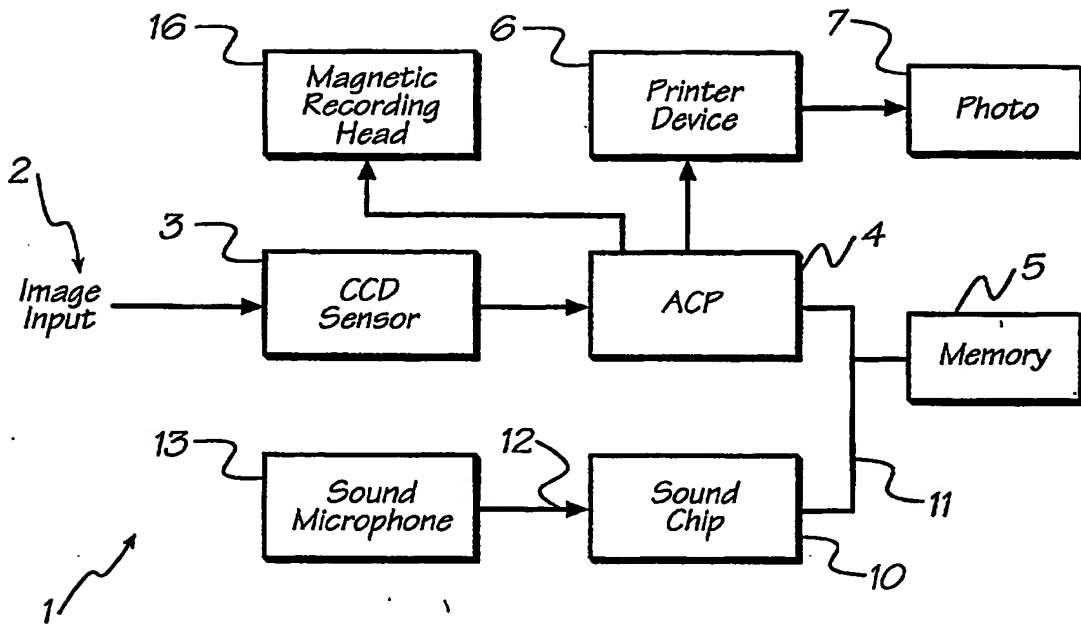


FIG. 1

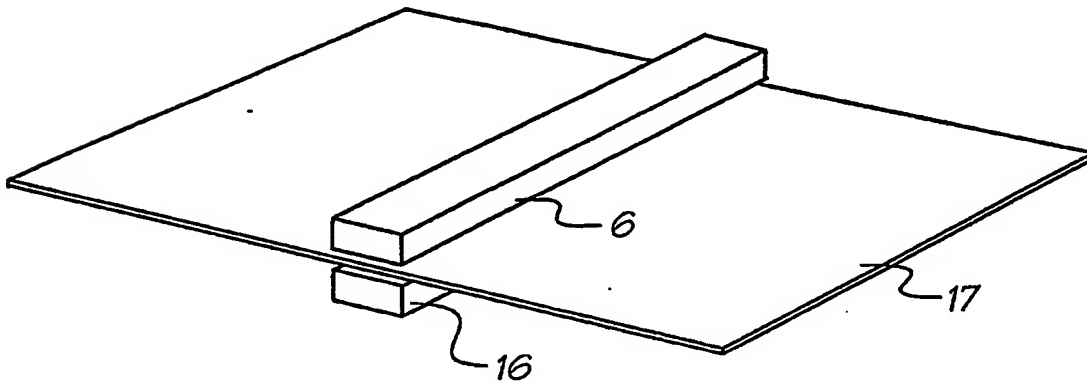


FIG. 2

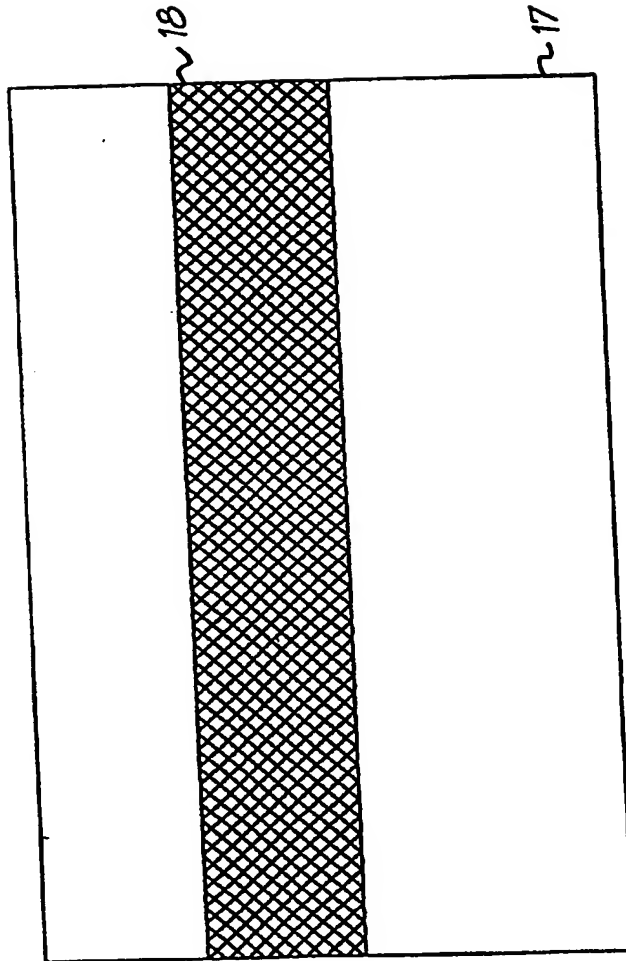


FIG. 3

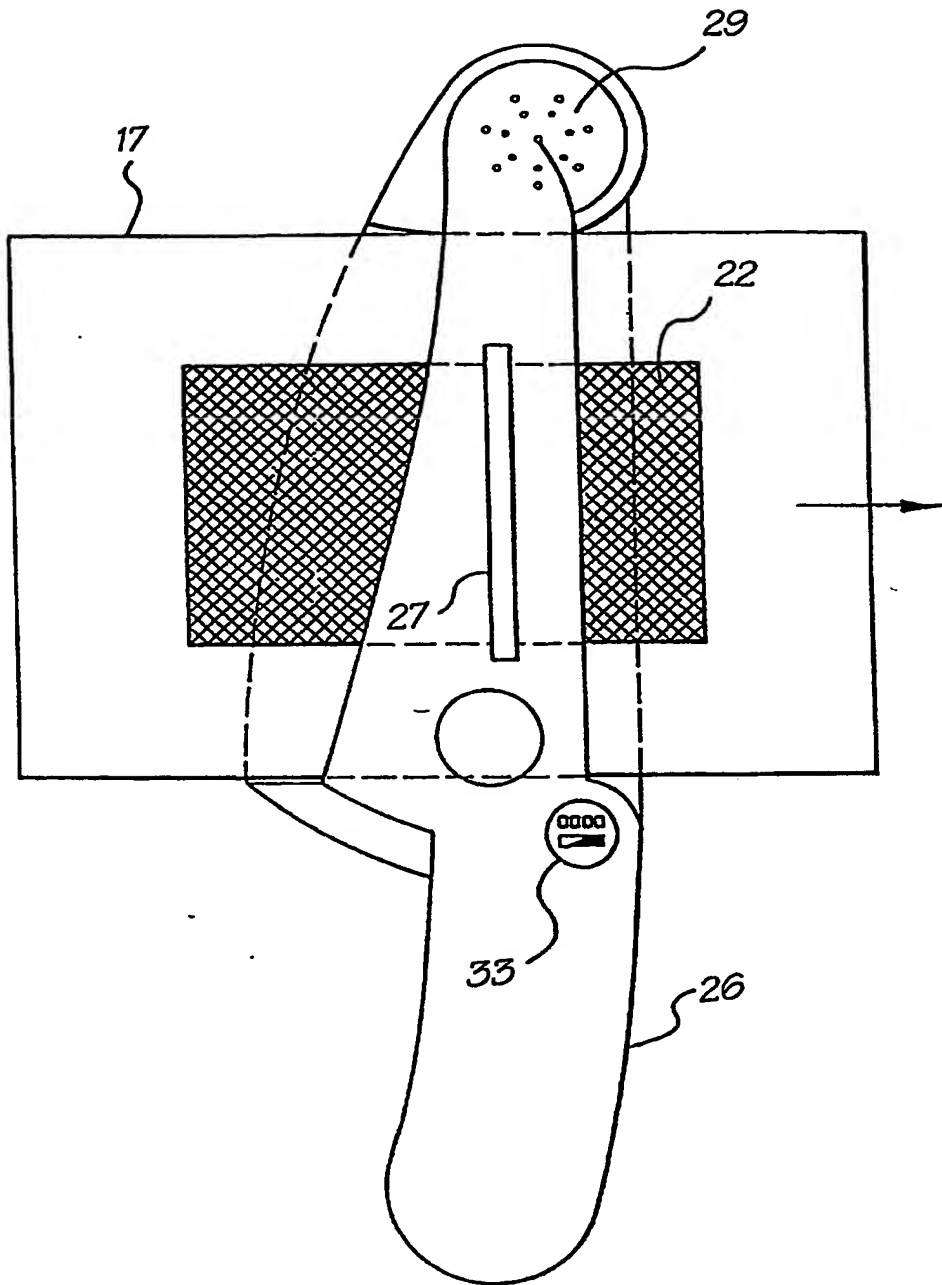


FIG. 4

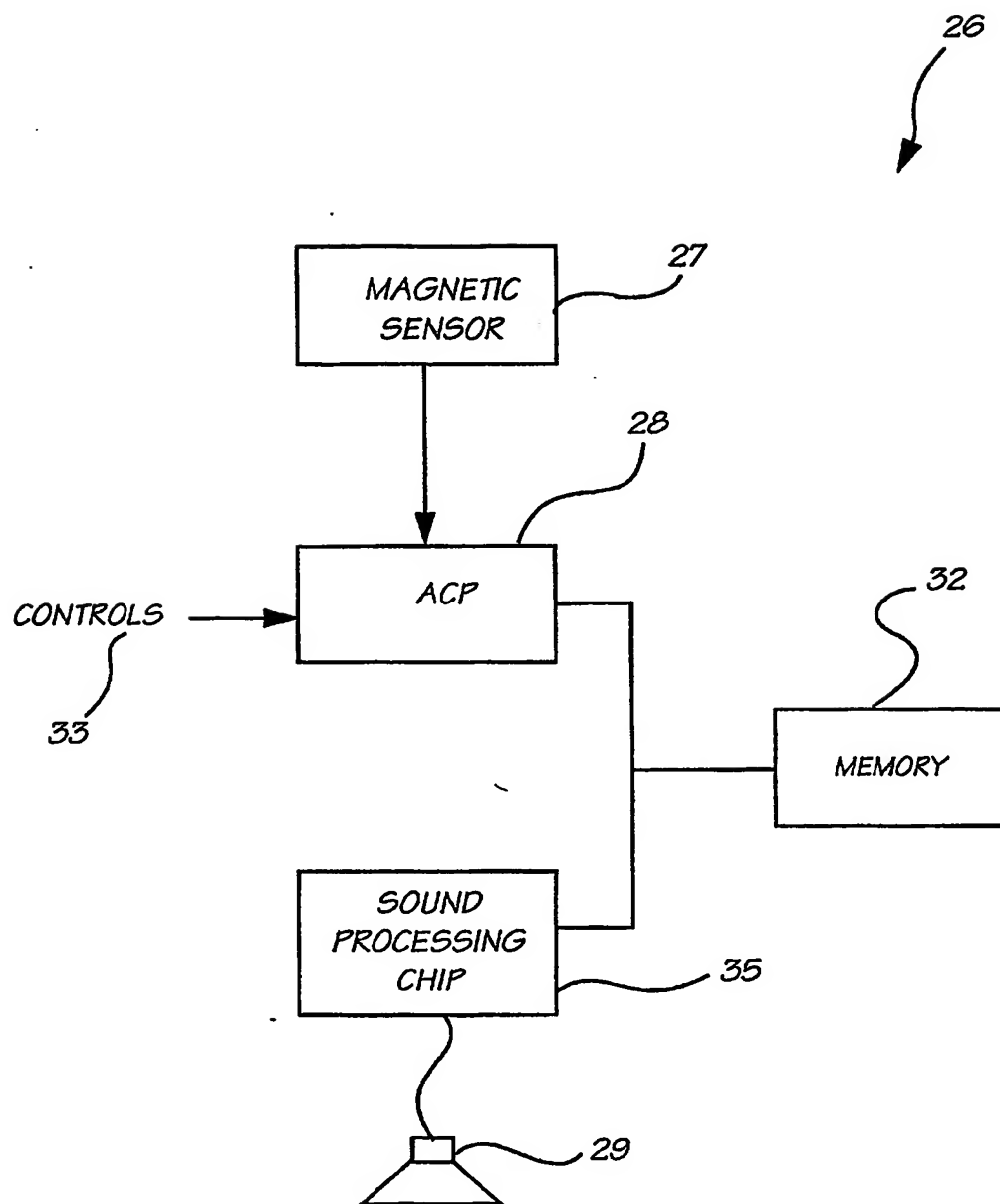


FIG. 5

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.